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THE RATHHAUS AT BAMBERG.

SOME of the towns and villages upon the banks of the Main have their Rathhauses erected upon most singular sites. That of Dettelbach, which has been previously illustrated in the *Builder*, stands upon an arch spanning a stream, and has the principal street of the town passing beneath it at right angles to the river. The Rathhaus at Marktbreit stands upon a bridge thrown across the city moat, and has a street passing beneath it. The Rathhaus at Bamberg has a still more remarkable site, as it is built upon the bed of the river, and tradition asserts that this singular site was selected because the town council, being on bad terms with the Prince Bishop, who held one bank of

"ON NO MAN'S LAND"
"The Town-council being at loggerheads with the Prince-Bishop, who held the left bank of the river & the Margrave who possessed the right, could obtain no land where on to build their Rath-haus, so they built it on the River's bed, that being NO MAN'S LAND."
A Tradition of the Main
A. W. Brewer. 1893.

THE RATHHAUS AT BAMBERG, ON "NO MAN'S LAND."

river, and the nobleman who possessed the other bank, could obtain no land whereon to build the Rathhaus, so they erected it upon the river's bed, that being regarded as "*no man's land.*" Whether the tradition is true or not, we have been unable to ascertain, but the singularity of the site selected has not been explained by any other theory.

Unfortunately the Bamberg Rathhaus was entirely rebuilt at the close of the seventeenth century. The present building is consequently in the Late Renaissance style, covered externally with somewhat rank paintings in distemper. The general effect is not unpicturesque, but there is nothing about it to account for its strange situation. In the old view of Bamberg, given in the *Nuremberg Chronicle*, a building that seems intended for the Rathhaus has projecting parapets and corbeled-out turrets at the angles; in other words, it is a fortified structure, which is somewhat strange, because the town itself was never either fortified or walled round, an omission which is accounted for, it is said, by the fact that Bamberg was regarded as a sacred city from the great relic of the true cross deposited in the cathedral by the Emperor and Empress, St. Henry and St. Cunigunda, who are buried in the cathedral; and now comes a question —Is it not possible (supposing this fortified building shown in the *Nuremberg Chronicle* to have been the Rathhaus) that it may have been erected on the bed of the river for the sake of its protection? Because, although possibly the warlike barons of the middle ages may have scrupled at robbing a church protected by so sacred a palladium, yet they may not have considered that this protection extended to the treasure chest of the town council. However, although we venture to suggest this explanation, we must acknowledge that it does not meet one objection, and that is, it completely fails to account for the almost equally singular site in such towns as Dettelbach and Marktbreit, which were fortified, and could not claim immunity from siege and sacking on account of any unusual sacredness.

Our illustration represents a town hall erected on a similar site to that at Bamberg. It is, however, purely an imaginary design, and is not founded upon any existing building, or any structure of former times. The site being the center of the river, the general outline has been treated in such a way as to bear some resemblance to a ship with its lofty poop rearing itself out of the water. As at Bamberg, the approach is from the center of the bridge, and the building has an open loggia round the upper story, a feature very common in the mediæval Rathhauses of Germany, good examples of which are to be seen at Brunswick and Hildesheim. For our engraving and the foregoing particulars we are indebted to *The Builder*.

[FROM THE BUILDER.]

WESTMINSTER ABBEY.

To do full justice to the subject within the limits of a single article such as this would be impossible; but we may endeavor here to give an outline of its history, combined with some critical considerations as to its architectural qualities.

The period when Westminster Abbey was originally built is lost in remote antiquity; and the foundation which history fails to record is still further obscured by fabulous tradition. Thus we are told that when the first church was erected here on a small island in the midst of a marsh known by the name of Thorney, the fabric was consecrated by St. Peter in person, who was ferried over from the Surrey side of the Thames for the purpose. The site originally is likely enough to have been as described, for the configuration of the ground and its low-lying position bear testimony to its probability. The name, too, indicates a minster to the west, doubtless, of the Cathedral of St. Paul; and the dedication to St. Peter appears to point to a designed connection between the two evangelists. King Sebert, who founded the one, is credited with the erection of the other, and the record is reasonable. But his was not the first building on this site at least. Roman bricks were found within the area of the present abbey church when the grave of Geo. Edmund Street was dug, and although they may have been simply old material brought from the ruins of Roman London or from some building nearer at hand, yet they may have formed part of some fabric erected on the spot. But doubt as to this becomes reality by the evidence of a recent discovery which has not yet been recorded. When the grave for Lord Lawrence was dug, Mr. Wright, the clerk of the works, found a portion of a Roman wall *in situ*; and a fragment of a tile with a pattern on it, and some red mortar formed with pounded brick, are preserved in his office. There is nothing to show the nature of the building, only that it was of Roman date. The Roman sarcophagus, which will be referred to later, was doubtless brought from elsewhere. But its position, when found, in relation to some building, points to the previous existence of a church on the same spot, at least as ancient as the stone cross lid which covers it. After enlargement by King Offa, the early buildings passed through the ordeal of ravages by the Danes, in common with so many others throughout England, the exposed position outside the shelter of the walls of London doubtless contributing to their fate. King Edgar restored them, and we hear of there being but twelve monks established there in his time.

We are on certain ground when we come to the days of King Edward the Confessor, whose palace, adjoining the monastery, on the banks of the Thames, has occupied so important a place in the history of our country to the present day. The rebuilding of the Abbey and its attendant buildings was begun and continued on an extensive scale. The new charter granted to the monks confirmed to them all their previous endowments, with many additions, and mention was made not only of the original consecration by St. Peter, but of the ravages made by the Danes. The church was consecrated in the most impressive manner, in the presence of a vast assembly, nobles and bishops having been summoned to be present from all parts of England. It occurred on the Feast of the Holy Innocents, December 18, 1065, and but a few days before the death of the king, who thus had the gratification of seeing the completion of that portion of the work which he had founded. The buildings erected by him mark a clear and defined epoch in the history of our national architecture, and on this account it is impossible to devote too much attention to the consideration of the remains, all too few and unimportant, unfortunately, that actually exist. These may be traced without much difficulty among the mass of superb Gothic work of later date, but the parts that remain are of the monastic buildings only, with one important exception, and the most elaborate parts have disappeared. Fortunately, the ground plan of the Abbey enables us to infer with fair probability as to the extent of the confessor's foundation, and, in addition, the documentary evidences are important and more or less reliable. As is well known, the buildings are described as having been erected in a mode of construction not then usual in England, and the "costly expenditure" spoken of by William of Malmesbury and Matthew Paris alike is amply attested by the large area of ground which they covered. Water was laid on to the Abbey from a spring at the southern end of the present Serpentine in Hyde Park, where a tablet still attests the fact. Large and extensive drains, which in recent years have been mistaken for subterranean passages, still exist in many directions, showing that the sanitary arrangements of the establishment were on an extensive scale. The bulk of these drains, which are formed of masonry, are still in use, and their size affords easy reason for the belief that they were secret passages, while tradition affirms that one actually exists beneath the Thames, affording communication with Lambeth Palace!

Sir Gilbert Scott, in his "Gleanings from Westminster Abbey," quotes from the lives of Edward the Confessor, written between the years 1065 and 1074, wherein the church is described as being raised high, vaulted, with square and uniform ribs, circular to the east, double vaulting to the aisles, of two stories, the cross building contrived to contain the choir in the middle, and to support the lofty tower, which, we are told, had a timber roof covered with lead. A description, somewhat similar, written in Norman-French, during the reign of Henry III., just prior to the rebuilding, speaks of the church having been built with large, square blocks of gray stone. The central tower is again spoken of, as well as the round east end, and two towers at the west front are named. Also a chapter house, toward the east, vaulted and round; bells, sculptured stones, and storied windows. These descriptions, if exact and reliable, would indicate that the confessor's church must have been a fabric conceived on much the same scale, although not the same design, as the Abbaye aux Hommes at Caen, and it may be, with some features which were only added to the latter building at a later date. We are not left to merely written description. The view of the church in the Bayeux tapestry indicates a building which corresponds fairly well with these descriptions, and it is remarkable for the loftiness of its central tower, which exceeds in the lightness of its proportions anything of Norman date that exists. In fact, the whole design may afford evidence that Norman architecture was not remarkable for heaviness of form when the fabric was relieved by high pitched roofs, steeples, and picturesque terminations. It may be remembered that the very truthful picture of Canterbury Cathedral, eighty or ninety years or so later than the date of the building under review, affords precisely similar evidence. Whether or not Edward the Confessor really completed the church is open to much conjecture. The extent of the undertaking and the shortness of the time would appear to render this very improbable. It is true that, as we have seen, the narrative speaks of the two western towers, and the Bayeux tapestry view shows a completed nave; but this may have been an anticipation of what was intended or imagined, rather than a record of fact. Mr. Micklethwaite, in his restored plan of the church at the early Norman period, adopts the view that the confessor's church only included the choir, the crossing, the eastern bay of the nave, the cloisters, and the southern nave wall, or its lower portion, as far as the northern cloister walk extended. Following the analogy of almost every other church, it may reasonably be supposed that the work was begun at the east end, leaving the completion of the western portion to a later time. The confessor having been buried so soon after the consecration (in front of the high altar) indicates distinctly that the choir, at any rate, was completed. The central tower, too, would require the transepts for abutments, and some portion, at least, of the nave for a similar reason.

Be this as it may, and recognizing the fact that the documentary evidence, which has been briefly referred to, is in favor of the entire completion of the church by the confessor, the belief that it was otherwise can only be reconciled to the evidences by the supposition that the nave was finished soon after the consecration. All the documents refer to a completed building. Beyond additions to the monastic buildings made in times following the Norman conquest, partly referred to in documents, but more clearly indicated by the surer test of the architectural detail, no alteration appears to have been effected in the Abbey church. The Infirmary chapel dated from the end of the century following the conquest. But the thirteenth century witnessed great changes in the forms of our Norman minsters, partly necessitated by badness of workmanship and hasty construction, but still more so by the love of change, which in old times as well as now may have operated badly for the preservation of ancient work.

We hear of the erection of a lady chapel in 1220, an addition doubtless at the east end of the circular aisle inclosing the presbytery. This was speedily followed by the demolition of the entire east end, as far as might be necessary, to make way for the magnificent fabric which still exists, the pride and boast of our country. The entire east end (except Henry VII.'s chapel), with its ambulatory and radiating chapels, the transepts and their double aisles, the Chapter House and the first bay of the nave, date from 1220 to 1260, the work having been begun at the east and extended to the west, the portion of the nave being necessary for the support of the slender piers of the crossing, and to carry the work to a uniform line from north to south. The next few years witnessed an extension of the work of rebuilding the nave. Four more bays were completed, and then the remainder was left, most probably joined more or less well to the Norman portion not yet removed, although the walls of the new aisles were erected in anticipation of the entire rebuilding.

Mr. Micklethwaite regards these four bays of the nave as also the work of Henry III., though executed later than the eastern bay of the nave. His reasons for this conclusion, which is a little at variance with the hitherto received dates, were stated in a paper read a few months ago at the London meeting of the Archæological Institute.

The four bays in question have commonly been referred to Edward I. Mr. Micklethwaite admits that the portion undoubtedly attributed to Henry III. (up to the first eastern bay of the nave) must have been finished before the other four bays were commenced; but he points out that the treatment in the latter is essentially exactly the same as in the eastern bay; that the differences are only so slight as might have been expected to occur in the recommencement of the work after a very short interval, perhaps with a new set of builders, and with a desire to make slight improvements on the previous work; the plan of the piers is improved, bronze bands are used with the shafts instead of marble, and there is a better treatment of the spandrels of the wall arcades; but the whole feeling of the work is the same. An examination of the building in reference to this theory convinces us that there is at all events great probability in favor of his view, and we have therefore adopted it. The nave remained in its incomplete state until well into the fourteenth century, when the clearstory and the vaulting were finished, and the long line of the nave roof was perfect from end to end. The west front, the central door and the two towers remained incomplete, and although the early years of the sixteenth century witnessed the completion of the doorway, etc., the towers remained only at about one-half of their present height, with no gable to the front, until the time when the western facade was completed, either by Wren or his pupil Hawksmoor, for there seems no positive certainty to which of these two architects the work is to be credited.

Old views of the abbey are not uncommon which show the appearance of the fabric without the towers. Among these, those of Hollars are supposed to be the most truthful, though we have great doubts whether he merits the reputation for accuracy commonly accorded to him. His northern view indicates how completely the fine portal of the north transept was hidden by a large gabled porch of late date, removed in the last century. Other views indicate a lofty and thin spire, once intended over the crossing, which, fortunately, was never erected. Henry VII.'s chapel, with its delicate and intricate work, stands on the site of the old lady chapel of Henry III.'s time, and may be considered as the last addition made to the abbey before the dissolution. Its erection has been followed by a long series of small remodelings and substitutions of new work for old, to the interior as well as the exterior, and it may be said that the scaffolding is never entirely away from the fabric, so large is its extent and so costly to keep in repair.

On entering Westminster Abbey, the first impression of a visitor conversant with our English cathedrals must be, in regard to its unusual proportions. The beauty of the groined roof may be probably equaled, the length may be exceeded, but the great height in relation to the width, and its attendant beauty, is not seen elsewhere in England. The spectator feels he is in a cathedral of the north of France rather than in an English one, until he observes the familiar forms of the detail which is the counterpart of work of the same date in our own country, only wrought in the most elaborate manner. Here is beautiful foliage, boldly undercut and admirably worked, rich moulded arches, polished Purbeck marble, shafted in profusion, and all the other items of detail which distinguish English work from French. The impression of foreign design, derived from the unusual height, is confirmed when the ground plan of the east end is considered. While previous minsters in England had, at most, a few semicircular chapels radiating from the curved ambulatory, or aisle, surrounding the presbytery, as at Norwich and some few others, here, instead, are six half-octagonal chapels, while the space of a seventh, the lady chapel of 1220, occupied the central position. The lines of their setting out are perfect, and the difficult problem of their arrangement, which can be studied in its development from the commencement to its perfection in the earlier French examples, is here found in its most complete form. The general resemblance to the east ends of Amiens and Reims cathedrals, if the plans be compared, will at once be apparent. On the north side, the square projection now known as Islip's chapel, and that of St. Benedict's on the south side, are suggestive of slender steeples, such as we see in the choir of the Abbaye aux Hommes, or those which once existed at Canterbury.

Within the presbytery, west of the modern face of the screen, buried beneath the superb mosaic pavement, are the bases of two of the piers of Edward the Confessor's church.

They are of plain Norman form, very similar to the somewhat later work at Winchester and elsewhere. They are valuable as being the only known fragments yet met with of the destroyed building, and they indicate not only that the center line of the existing church was the same as the former one, but also that the latter is wider. The Gothic building could, in fact, have been erected around and over the older one, so far as regards the central portion.

The pavement before the screen deserves special attention as being Italian Opus Alexandrinum, formed of rare marbles, derived most probably from the ruins of ancient Rome, mingled with our own Purbeck marble, and laid in a pattern which is completely mediæval Roman. There is another mosaic floor of plainer design in the space behind the screen, so well known as Edward the Confessor's chapel. It will be noticed that, while the mosaics of the pavements are of porphyry and marbles, those of the tomb of Henry III. and in the shrine of the confessor, where they remain, are of glass.

A small portion of the decoration of the celebrated coronation chair is of the same material. The importance of these art works, it may be remembered, is enhanced from the fact that, apart from the value of the design, there is but one other pavement of Opus Alexandrinum in England—that at Canterbury, where, however, the design is totally different; and no example at all of glass mosaic is extant except a small portion of an ancient Roman pavement at Aldborough. The

detail of the screen, the eastern side being ancient, of fifteenth-century work, illustrates incidents in the life of the confessor.

The transepts have double aisles, the arches being of acute lancet form. The former rose window of the north transept, lately replaced by a new one, was of fifteenth-century design, which it would have been a pity to remove, but that it was a copy executed early in the last century, and found to be all to pieces when the recent recasting of the front took place. The stained glass which then filled it has been replaced, but with the absurd alternation of cutting off the feet of the figures to make them fit the new tracery, which was apparently designed without any intention of preserving the old glass, although it is a good specimen of glass painting of the last century, when such works were hardly ever executed.

The nave presents a curious study of Gothic details of more than usual interest, from the fact that while the general design of the whole is similar in the early and the later parts, which harmonize well in this respect, yet the detail in each case indicates the varying periods of the execution, and the junction at the point where the works of the two periods meet is worthy of observation. The wall arcades have been of great beauty, but are now much cut into for the insertion of modern monuments.

In the space beneath the southwest tower, inclosed by a fifteenth-century stone screen, is deposited the old font of the abbey of the same date, and the window over it, as well as the corresponding one of the sister tower, is filled with contemporary stained glass. The clearstory windows of the east end are also filled with old stained glass. The pavements are mostly modern, but several specimens of encaustic tiling remain in the chapels, while the chapter house has a pavement all but perfect except for wear.

At the south end of the western walk of the cloisters an ancient arched recess is now being opened, and a mass of elaborately worked late Norman detail, built in as old material, has been discovered. A good many pieces of similar stonework have been found in recent years. Elsewhere are deposited various interesting fragments of stonework, including a Norman shaft of later date than the confessor's time—probably from the former cloisters.

Passing over many curious features of the monastic use of the cloisters, it will be noticed that the western aisle of the south transept is carried above their eastern portion. A reference to the ground plan, and some irregularities of line,* furnish some evidence of interest relative to the size of the confessor's church. Here the rebuilding joined the early work, and it is apparent that the existence of the east walk of the cloister rendered it imperative to modify the new aisle in the way named. The south wall of the south walk is the ancient north wall of the confessor's refectory, the masonry of which is here and there visible. The southern limit of the confessor's cloister is thus determined, while the northern limit was the wall of the south aisle of the nave. One of the sides being thus determined, these considerations render it almost a certainty that his cloisters were of the same size as at present. Entering from the east walk, the superb double arch of the vestibule of the chapter house, on which traces of color decoration are still visible, is passed, and the chapter house is reached. This beautiful apartment, with its restored vaulting and windows, is a good example of Sir G. G. Scott's genius in "restoration," here exercised with better reason and happier result than in some other instances; its ancient wall paintings are of much interest, and all can be studied with advantage. Its present beauty is in marked contrast with the appearance indicated by not very old views, which show it shorn of its window tracery and vaulting, and filled with shelves and presses wherein were stored the records of England. Bad as are the acoustic properties, it is matter of surprise how the early parliaments managed to get through their work within it. Perhaps the debates were shortened in consequence. To the south, the confessor's work is very apparent, and in the carefully locked chapel of the Pyx, the plain cylinder shafts, with their semicircular arches and vaulting, still remain. Although entrance is generally impossible, a bay or two of similar work is capable of being inspected at the southern end, and it will be noted that an attempt has been made to decorate the plain caps with sculpture at a later Norman period. The extent to which this practice was indulged in throughout England, and the manner in which early Norman work has been made to resemble that of later date, has not even yet been fully recognized. It will be noted that the confessor's masons have invariably worked their stones with diagonal tool marks, such as exist equally in work after the conquest. Over the range of vaults, which were formerly the monks' day room, is the long gallery now used as Westminster school, formerly the monastic dormitory. The walls are, for the most part, of the confessor's date, and at intervals a window or two may be in-pected. One was laid open for inspection, in perfect condition, when the class rooms of Ashburnham House were erected in 1883. It was wide for its height, the arch stones and jambs being of Caen stone, the favorite freestone which is used throughout the early work; the stones were sawn, but the arch stones were not truly worked, and the setting had to be accomplished by wide joints. All the freestone is set with very wide joints; those to some of the cloister stones measure 1⅛ in. in thickness. When the works referred to were carried out, a series of seven closets of the necessarium were found built above one of the sewers already referred to. The range had extended, apparently, beyond Inigo Jones' Ashburnham House. Below, part of the Misericorde was met with, and traces of inscriptions scribbled on the walls in idle moments remained; one of these, in black letter, having reference to a certain pie, referred to some good cheer of long past days.

Above, on the first floor, close to the closets, a mediæval fireplace was found, with a comfortable arrangement of the hob, which enabled some creature comfort to be kept warm when wanted. Some three or four others have been found elsewhere from time to time. These curious relics of the past were all cleared away for the new works, as were also some traces of ovens, which were laid open for a short time at the southwest angle of Ashburnham House. They were formed of thin tiles. It is of the more importance to place their discovery on record, since they were seen by but few people at the time, and the position of the abbey kitchen has been the subject of discussion.

It may be added that the western gable of Ashburnham House is ancient, and it is evidently an external wall.

(To be continued.)

* A word of comment is required here. It will be observed that Mr. Micklethwaite's restored plan shows the lines of the cloisters very much askew, and on the lithograph plan, based mainly on a careful plan prepared some years ago by Mr. R. Phene Spiers, no such distortion is visible, though the western walk of the cloister is shown a little out of square with the nave wall, treading toward the west as it recedes from the church, and this, as far as we can judge, is correct; at least, if there is any deviation from the right angle here, it can hardly be more than that. Mr. Micklethwaite believes (as is indeed most probable) that the lines of the present cloister follow those of the confessor's cloister; but, if so, he has certainly exaggerated the skew element on his plan. On the other hand, there is a perceptible bend westward in the line of the east walk of the cloister, at the point where it leaves the angle of the transept, as any one may see by standing at the transept door and looking along the cloister aisle southward; the bend here is as decided a deviation from the rectangle as Mr. Micklethwaite's plan shows, but this deviation is only, as far as the eye can judge, in this portion of the east cloister walk. But the fact is that the various slight deviations of line in a great mediæval building like this, built and added to at various periods, could only be realized with absolute accuracy by a survey with the theodolite, a piece of work we could hardly have undertaken, even if the authorities of the abbey could have found it convenient to permit it. But we decline to believe, on the evidence of our eyesight (including a bird's eye study of the cloister garth from the roof of the nave aisle), that the present cloister is so much askew as the ancient one is shown on Mr. Micklethwaite's plan.

HIGH BUILDINGS.

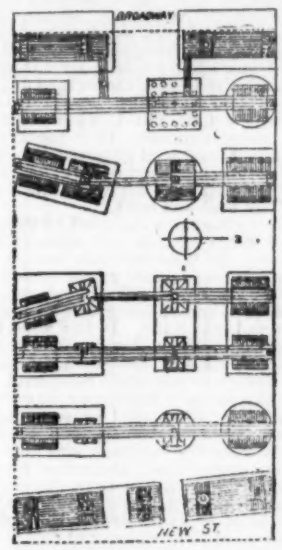
THE evolution now going on in the method of constructing city office buildings is very interesting. The

THE NEW MANHATTAN LIFE INSURANCE BUILDING.

rapidly growing value of real estate in business centers made it necessary to increase the height of the buildings. The old materials, stone or brick, put a natural limit to the height to which it was economical to build, as the necessarily thick walls of very high buildings occupied too much floor space in the lower stories. Within the last few years the cheap production of iron and steel has brought about their employment for the main supporting members of buildings, and at one stride the practicable and economical height of office buildings has been increased to two or three times that of buildings constructed in the old way. The new method, called the skeleton frame construction, reduces the use of brick and masonry to a mere covering shell. The masonry of each story is supported on steel beams framed between columns, permitting such thin walls, even at the base, as not materially to encroach on the available space.

One of the features of this evolution has been to concentrate the weight of the buildings at the isolated points from which the columns rise, instead of distributing it over a large continuous area, as the walls of the old buildings do. This concentration calls absolutely for a different style of foundation. Where it is attempted to carry heavy loads on the outer edges of a building the tendency is to cause settlement and consequent cracking. The solution of the problem is either to carry the weight from the edges back to the centers of the foundations by means of lever beams or cantilevers, or to carry the concentrated loads down to rock or some other unyielding material. The necessity of doing this is augmented by the fact that it is not sufficient simply to get an adequate foundation for a building, but it is necessary also to guard against danger from adjacent excavations in the future. The material beneath buildings is now often under such pressure that it will eagerly seek an escape laterally when an excavation is made alongside.

A notable example of the new method of construction is the building of the Manhattan Life Insurance Company in Broadway, near New Street. The weight of the building is estimated at 21,600 tons, or a little more than 43,000,000 pounds, to which must be added 2,400 tons, the pressure exerted upon the foundations owing to the force of the wind acting upon the sides of the building and trying to overturn it. The weight due to human beings and furniture is put at 7,000 tons, giving a total of 31,000 tons, or 62,000,000 pounds, to be sustained by the foundations. This enormous weight could not be carried safely on the natural soil, which consists mainly of mud and water-bearing sand overlying the bed rock. The latter has a fairly level surface about fifty-four feet below Broadway. If piles

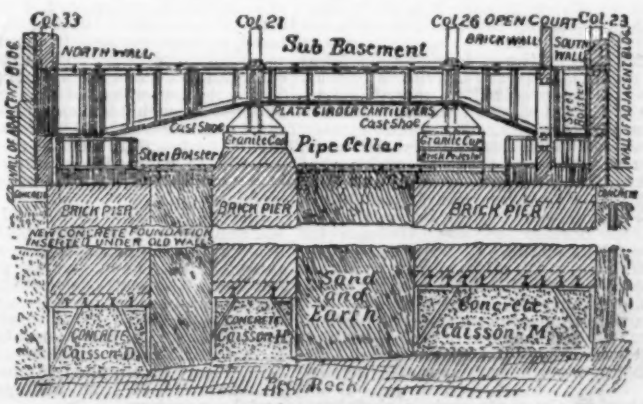


THE GROUND PLAN.

had been driven all over the 8,170 square feet of the building lot as close together as the law permits—that is, thirty inches between centers of piles—a little more than 1,900 could have been used. This would have given an average load per pile of 47,000 pounds, or 7,000 pounds more than the building laws allow. A pile foundation was, therefore, not possible, and it might have been dangerous in the case of future excavations alongside. The nature of the soil made it impracticable to reach rock by means of an open excavation, especially in view of the heavy buildings adjoining. The pneumatic process was, therefore, employed to carry the foundations down to bed rock, and it enabled the architects to reach the rock without disturbing in any way the material except in a volume equal to that of the caisson. The pneumatic method, which has long been used in sinking foundations for bridge piers, had never been employed in building construction, and the credit for the adaptation of the process belongs to the architects of the building.

A caisson consists of an inverted box. In this box air pressure is maintained equal to or slightly above the pressure of the water, so that it is impossible for any water to enter. Excavation is carried on by laborers in the caisson, which sinks gradually down as the excavation advances. Masonry on top of the caisson is built up as the caisson goes down.

The caissons of the Manhattan building are of steel. The working chambers were eight feet high, and brilliantly lighted by electric incandescent lamps. The average rate of sinking was four feet a day, and generally about eight days were required to sink each caisson. After the lower edge of the working chamber had reached bed rock the rock was cleaned and leveled inside of the chamber. The chamber was then filled with concrete, and the caisson and the pillar of brick ma-



CROSS SECTION OF FOUNDATION.

sonry on top became like an excrescence of the natural rock, hard and unyielding like it.

Fifteen caissons are used for the Manhattan building, of which four are cylindrical, with diameters from 10 feet to 15 feet, and eleven are rectangular in plan. The largest one of the latter is 21½ feet by 25½ feet. The first caisson was delivered at the site April 13, 1893, and the last pier was completed August 13, 1893. The piers cost nearly $150,000 in all, or about 10 per cent. of the total cost.

The building has a frontage on Broadway of 67 feet. Its depth is 119 feet on the north line and 125 feet on the south line. The building proper is to have seventeen stories on the Broadway front and eighteen stories on the New Street front. It will be 342 feet high from the Broadway sidewalk to the top of the main roof. Rising from the main roof on the Broadway front there will be a tower, which will make the height of the building from the Broadway curbstone to the foot of the flagstaff 350 feet, or 70 feet more than the steeple of Trinity church.

The proper design of the steel construction was a matter of first importance, on account of the weight and the height of the building. The element of height made the influence of the wind a very important factor. The total weight of the building, with the exception of the front wall on Broadway, is carried on thirty-four columns. Of these columns thirty-two are of cast iron up to the fifth floor level, and of steel above this elevation. The other two columns are of steel throughout. Between the columns are framed heavy steel beams, which, in their turn, support smaller beams, between which flat arches are sprung, forming thus the floors. Careful attention has been given to the fireproofing of the building, each exposed surface of a column or beam being covered by a thickness of four inches of tile. Experience shows that unprotected iron will crack or bend under fire. The Broadway wall supports its own weight, but is anchored into the steel frame for lateral support. It is nearly six feet thick in the basement, and is of granite up to the first floor level, as the pressure per square foot exceeded that which the building laws allow for limestone, of which the rest of the wall was built.

The building has been designed to withstand a wind pressure of thirty pounds per square foot against its entire surface. To illustrate this force, it may be mentioned that such a pressure would blow an empty passenger car off the track. The wind pressure against the long sides of the building will be sustained by the solid front and rear walls. If the wind blows against the ends of the building, it will be resisted by the brick party walls, which run continuously from Broadway to New Street up to the sixth floor level. The southern side of the house is broken by an open court above this elevation, and the wind pressure against the upper stories is taken care of by knee braces riveted in the corners between columns and floor beams. The tower, which rises 107 feet above the roof, on account of its exposed position, has been planned to resist a wind pressure of fifty pounds per square foot.

The weight of iron and steel in the building is nearly 12,000,000 pounds, of which 2,000,000 pounds are contained in the construction below the Broadway sidewalk. The metal construction from the level of Broadway to the roof was erected in three months. The cost of the building lot was about $1,500,000, and the cost of the building itself amounts to about an equal sum.

The structure will be the highest office building in the world, and one of the most conspicuous examples of this typical American creation, the skeleton structure. It will be interesting to watch the development in the construction of office buildings. It is quite likely that in some future building the considerable value of well-located rooms underground will bring about the plans of sinking one or more pneumatic caissons over the entire lot to be occupied, and of carrying the columns themselves through this. Then the caissons could be converted into a room or rooms. This plan would be entirely feasible, and in view of the space gained, probably economical. As the walls could be made absolutely tight, there is no reason why by the use of proper means of ventilation, and of tile or marble finish, attractive rooms for restaurant or other purposes, could not be obtained. It would certainly save time to go down one or two stories instead of going up eighteen or more.

The great modern office building may really be called a bridge on end, and it calls for the same engineering skill in design, both superstructure and foundations, that is given to large bridges. The architect and the engineer must work hand in hand if the results are to be obtained that will endure and be worth the vast sums expended.—*N. Y. Sun.*

A REMARKABLE ARTESIAN WELL.

THE engraving illustrates the overflow from a remarkable well recently sunk for the town of Spalding. This well was completed at Bourn, Lincolnshire, by C. Isler & Company, London, as a means of supply for Spalding. No records, as far as we know, says *The Engineer*, are published of springs being tapped in England yielding a larger quantity of water than this one at Bourn.

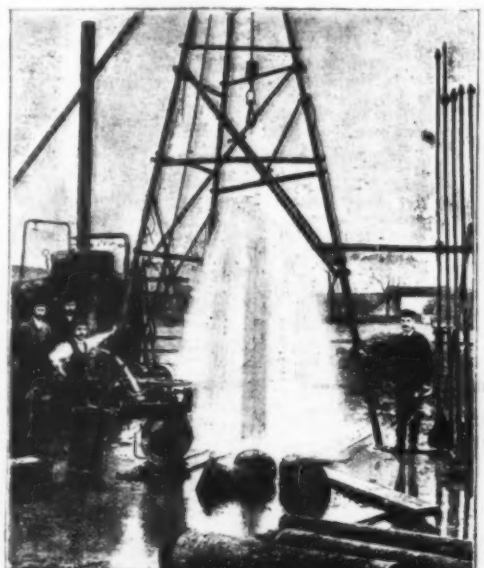
At a depth of 100 ft. from the surface the yield was 1,872,000 gallons per day, and on the advice of Messrs. Isler & Company it was resolved to carry the bore deeper, with the result that at 134 ft. over 5,000,000 gallons per day are now obtained. The overflow really proved wonderful, and unless means had been taken for carrying this water away into a dike, which runs into two rivers, the country around would have been flooded. Precautionary measures had to be taken in this instance, as in a former one, to insure that no water should escape outside the tube. Owing to the great pressure which exists there are several boreholes in neighboring districts which allow a great portion of the water to escape outside the tubes, causing an unnecessarily great waste.

In the Bourn well there are three tiers of pipes inserted in the borehole, and each tier of pipe brought to the surface, and each driven tightly into the soil, the annular space being filled in with specially prepared cement.

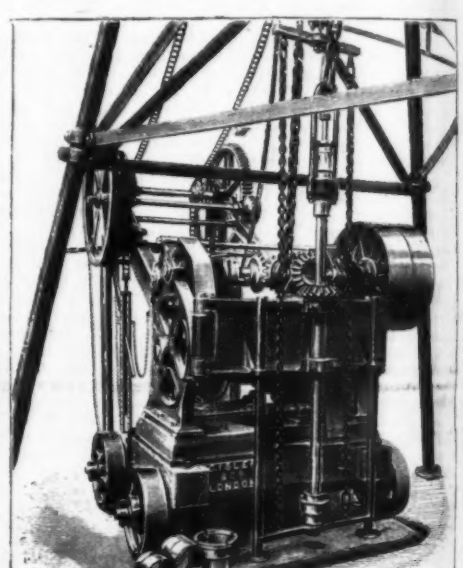
Previous to tapping the main springs chalybeate water was met with at 65 ft. 10 in. from the surface. This was safely eliminated by the driving of the 18 in. pipes, which are the main supply pipes of the boring.

At 78 ft. 6 in. from the surface the main springs were tapped in the Lincolnshire oolite, the water rising very slowly, and took twenty-four hours to overflow from this depth. But on continuing the boring deeper the volume of water rapidly increased, with the result that at 100 ft. the supply was 1,300 gallons per minute overflow, or 1,872,000 gallons per day. At 120 ft. from the surface the amount of overflow was 1,800 gallons per minute; and at 134 ft. nearly double the amount, namely 3,480 gallons per minute, giving a result of 5,011,200 gallons per day. The pressure remained at each depth the same, namely, 10 lb. to the square inch. The water flows, by gravitation, through ten miles of pipes to the company's reservoirs at Spalding.

We give an illustration of Messrs. Isler's Crown diamond rock boring and percussion boring machinery. The engraving also shows the gantry standing over the machine for withdrawing the tube and the core, or for carrying the monkey or other apparatus for driving the percussion tools or the tubes, and also for suspending the boring tool and giving the required feed downward.



ARTESIAN WELL AT BOURN, LINCOLNSHIRE.



BORING MACHINERY.

GAS ENGINES FOR DRIVING TRAMCARS.

THE application of gas for driving tramcars has recently attracted considerable attention on the Continent and has provided material for two lengthy papers in the pages of the *Journal fur Gasbeleuchtung*. From reprints of these we observe, says the *Journal of Gaslighting*, that much of the matter is common to both, and the substance of the two papers may conveniently be presented to our readers in one article. Herr A. Kemper, chief engineer of the Dessau Works of the German Continental Gas Company, communicated one paper to last year's meeting of the German Association of Gas and Water Engineers, and Baron Gostkowski, of Lemberg, is responsible for the other.

Both the authors enumerate the various methods which have been used or proposed for the driving of tramcars. Steam is dismissed as unsuitable for use on roads, on account of the excessive weight of the locomotive cars and the heavy permanent way required, apart from the annoyance caused by smoke, steam, ashes and sparks escaping. Compressed air is used for driving tramcars at Berne, but it is too expensive for general adoption. For the same reason, or for want of exact information, carbonic acid and ammonia motors, as well as Connelly's engine for the consumption of vaporized naphtha, are discarded. Herr Kemper alludes to the cable tramway; but he considers it only suited for use on very steep gradients, where a system dependent for traction on the adhesion weight of the cars would be quite inadmissible. The first cost of cable tramways is high, and the breakage of the rope brings traffic to a standstill. There remain then only three sources of power deserving consideration—viz., horses, electricity and gas.

Objection may be taken to the use of horse power on sanitary grounds, as well as on account of the lack of precision in stopping, and the generally uncertain control over power possessed of volition. On the other hand, horse power readily adapts itself to the resistances to be overcome, and on rises and curves a horse can exert ten times its normal power for a short time. The horse power unit of 75 second meter-kilogrammes adopted in mechanics represents the force a horse can exert continuously, and it is evident that mechanical motors for tramcars must be of at least 8 horse power in order to cope with considerable temporary obstacles. The cost of horse traction for tramways will be estimated later.

Electric tramways have found extensive use in America, and they are viewed favorably in Germany. It is evident that, in order to gain adoption, gas must be proved to be able to compete with electricity for driving cars. The methods of applying electricity for this purpose and its cost in each case must be briefly considered. The chief difficulty with electric cars lies in the conveyance of the energy to the motors attached to the car. There are three methods by which the energy may be supplied to the motors—viz., (1) from accumulators, (2) from underground cables, (3) from aerial conductors.

The ideal method is by means of accumulators, as each car carries its own source of power and is independent of conductors; but trials in many places—notably in Brussels and Hamburg—have not resulted in its general adoption. The reason lies in the heavy weight (from two to four tons) of the accumulators, their unsuitability for yielding a varying current, the necessity for changing them every three to five hours and the great loss of energy rendering the cost of working extremely high. The second method of supply—with an underground conductor—has also been but little adopted. Its first cost is high, and the narrow conduit open to the street is objectionable to other traffic, besides needing very perfect drainage, if interruptions through access of water and various objects are to be avoided. In Budapesth, where this system is at work, few interruptions occur; but the expenses are very high. Thus the only generally available and cheap electrical tramway system is that with overhead conductors, which is in operation in many German towns. In expense of working, it compares favorably with horse tramways; but the initial outlay is greater. On æsthetic considerations it must meet with disapproval, on account of the conductor being placed some 18 feet above the roadway, with its obstructive supports disfiguring the paths.

Each track, according to this system as in use at Halle, has two overhead conductors, joined at intervals of about 200 yards, so that a break in the working conductor may not cause the interruption of the current throughout the line. Beneath the body of the car are two electro-motors, each of 15 nominal horse power and each driving one of the main axles. They work either together or singly. The motors make 1,200 revolutions per minute; and by cog or chain gearing this number of revolutions is reduced in transmission to the driving axles. The resistance boxes and regulating apparatus are attached to the platforms. The cars weigh about 5 tons, or, with the complement of 28 passengers, about 6½ tons. For the rate of 10 feet per second on a level track, Herr Kemper calculates that the electro-motors must develop about 4 horse power, which, allowing for losses, means at least 6 horse power generated at the central station. The electro-motor cars are superior to others on up gradients. They are capable of maintaining their normal speed on a rise of 1 in 15. According to the statement of an electrician, the working expenses, including depreciation, of this system of electric tramways, may be taken at 20 to 25 pf. per kilometer run (4d. to 5d. per mile). The working expenses of a single horse tramcar are estimated at 22 to 28 pf. per kilometer. So the electric system is cheaper in working; but the greater capital outlay makes the return nearly the same.

Tramways with gas-driven cars may now be considered. The receptacles for carrying coal gas on the cars resemble the reservoirs used on railway carriages for compressed oil gas and the compressed air reservoirs used on the tramcars at Berne.

The gas supply may be taken from the street mains; but one or more compressing and filling stations are required. These should cost, with all accessories, from 400*l.* to 600*l.* According to Herr Kemper's project, an 8 horse power gas engine drives a compressing machine which is capable of compressing 2,100 cubic feet of gas (at 8 atmospheres) per hour. The cylinder of the compressor has a diameter of nearly 6 inches and a stroke of nearly 13 inches. A pipe 1¼ inches in diameter leads from the compressor to the storage vessels, which have a united capacity of 400 cubic feet. At 8 atmospheres pressure they can give to the car reservoirs 800 cubic feet at 6 atmospheres—sufficient to charge two cars.

The charging of a car is accomplished in about a minute. The compressing station is only 13 feet wide by 20 feet long. The gas engine used to drive the compressor consumes about 8 per cent. of the quantity of gas compressed, or 1 horse power compresses about 330 feet.

Two systems of cars have been devised for propulsion by gas power. The firm of Guillieron & Aurein, of Vevey, Switzerland, are the manufacturers of the cars used on the Neuchatel to St. Blaise line. Neither of the authors is able to give much information on the working of these cars. They weigh 6 tons each, and carry 20 passengers; they are driven by an 8 horse power twin gas motor on one of the platforms, and consume, according to different estimates, from 24 to 33 cubic feet of gas per mile run. The line is a little over three miles in length, and the car reservoirs hold suf-

cient gas for the out and home journey. The cars cost 600*l.* each; but the power provided seems scarcely sufficient to overcome the rises—up to 1 in 30—which occur on the line. The condensing arrangements are perhaps superior to those of the other system, which is that of Herr Luhrig, of Dresden. Trial runs have been made on the Dresden tramways with cars constructed on Luhrig's plan; and the cost of working is calculated therefrom by both authors. There are ten small gas reservoirs on each car—two on the roof, the remainder beneath the body of the vehicle—having a united capacity of from 45 to 65 cubic feet. As they are filled to six atmospheres pressure, they contain, when freshly charged, six times this volume of gas. The pressure is reduced by means of regulators similar to the Pintsch governors on the supply pipe to the engines. These are two, each of 7 to 8 horse power, so placed under the seats that the fly-wheels are outside and below the seat backs, but do not protrude beyond the sides of the car. Both gas motors drive one shaft, which gears by cog wheels on a second shaft, from which, by means of chains, the power is conveyed to the axles of the car.

By the aid of controlling levers, the driving shaft can be caused to turn at three different speeds. The slowest is for use when the motor runs free, as during short stoppages; the medium one, for ordinary running, and the fastest, for heavy work. The controlling levers on the driver's platform are as follows: A foot lever for controlling the gas motor; a hand lever for altering, by means of a clutch coupling, the rate from medium to fast, or *vice versa;* a hand lever for controlling the direction, backward or forward, of traveling; and a hand wheel, which, by means of a friction clutch, simultaneously applies the brakes and allows the motor to run free. By means of these, any desired maneuver can be carried out with greater ease and simplicity than might at first glance be supposed. Ignition is effected by means of a small electro-magnetic apparatus. The condensing water is carried in a tank on the top of the car and circulates automatically; so that it seldom needs replenishing. Galvanized iron plates, with flaps opening to permit of inspection, shut off the motors and machinery from view. No noise from the machinery is perceptible in the car while traveling; but when stopping the machinery running free makes a slight noise, and a little vibration may at the same time be felt. The large car for level roads can carry at least 29 persons; but Herr Luhrig has constructed smaller ones for use on heavy gradients.

The first cost and the working expenses of the Luhrig tramcars are discussed at length by both authors; but as they take somewhat different data for the calculations, the results are not strictly comparable with one another, though each may be fairly compared with the cost of electric tramway traction arrived at by the same writer. Herr Kemper estimates the cost of construction of a tramway five miles in length, with all appurtenances for gas, electric and horse traction. The respective amounts are 30,000*l.*, 38,000*l.* and 28,000*l.*; so that the first cost of a gas tramway is slightly higher than that of the horse line, but considerably lower than that of the electric tramway. This is largely due to the necessity for constructing a central station for the supply of electrical energy; whereas every town where tramways are adopted will have a gas works.

As the tramcar motors work almost entirely in the daytime, when the ordinary consumption of gas is at the minimum, the use of gas for driving them would tend greatly to equalize the consumption in a town, and so indirectly render the management of the works an easier task than it is at present. Then, taking gas at 3s. 4d. per 1,000 cubic feet, the cost of working, with allowances for depreciation of rolling stock and machinery, is arrived at for a year; and from this the cost per car per mile run is calculated. It amounts to almost exactly 3d. If gas is taken at 4s. per 1,000 cubic feet, the cost per mile per car would be about ¼d. higher. Herr Kemper computes that the working expenses of a one-horse tramcar are 4s. 2d. to 5s. 4d. per mile; those of an electric car, 3s. 8d. Taking the average number of passengers in the tramcars in Germany in 1889, he reckons out at low fares the receipts of such a line as the one projected above. He finds that, whereas the electric line would yield no return to shareholders, the gas motor line would certainly pay 6½ per cent. on its capital.

Baron Gostkowski, who studied the working and cost of gas-driven tramcars with a view to recommending their adoption in the town of Lemberg, takes the heating power of Lemberg gas for the basis of his calculations, and arrives at nearly the same result as the Dresden gas actually gave in working. He then calculates, with considerable detail, the gas consumption and working expenses for the projected line of 5½ miles in Lemberg. As the gas works will be under the municipal authorities at the time when the tramway could begin work, he takes gas at the cost price of 1s. 10d. per 1,000 cubic feet, and finds that traction would then cost about half of the average cost of horse traction on the tramways of a number of Continental towns. Finally, he computes the cost of traction of a car by electricity on the aerial conductor system; and, allowing for interest on capital, he shows the gas motor car to be 24 per cent. cheaper in working than the electromotor car. He further states that Connelly's system of driving cars by gas generated on the cars themselves from naphtha, which has been adopted in Chicago and other American towns, can be worked there at one-third the cost of horse tramways, and one-half that of the electric line. Though it is being tried on one of the lines in London, this oil-gas motor is more likely to be adopted in oil-producing countries than elsewhere.

ANTI-FRICTION COMPOSITIONS FOR BEARINGS AND OTHER PURPOSES.

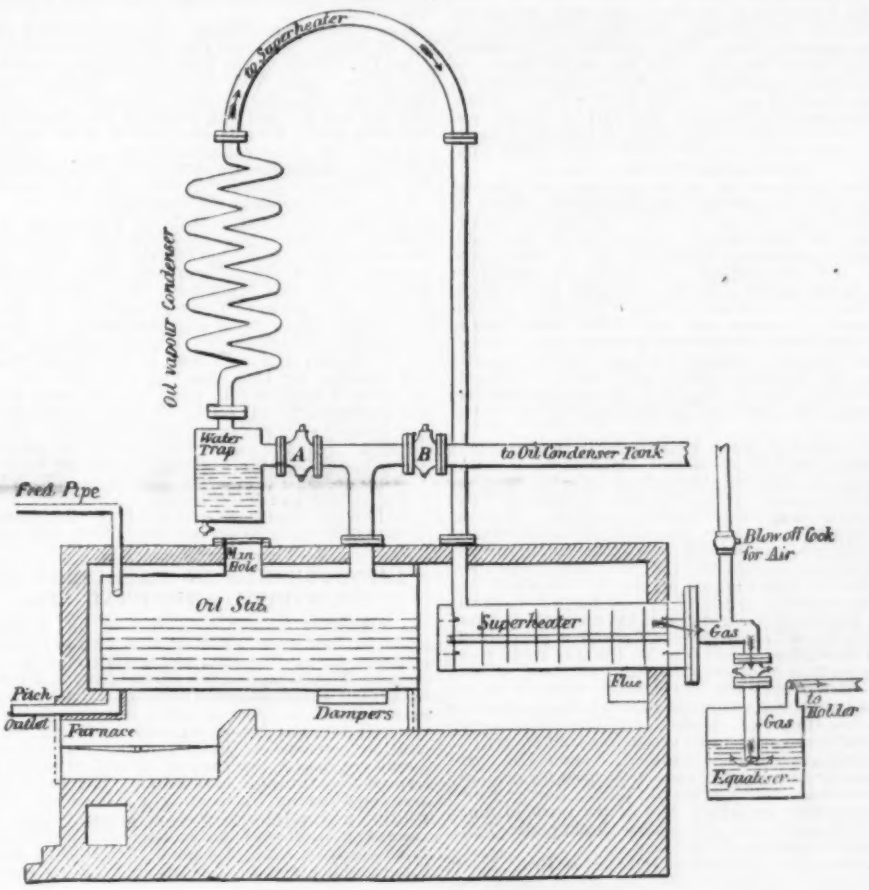
By H. F. HOVELER, London.

FOR packing rings and segments a mixture is used containing about 30 per cent. of asbestos powder and 70 per cent. pulverized white metal; for bearing shells, footsteps, bushes, etc., a similar mixture containing about 30 per cent. asbestos powder, 20 per cent. graphite powder, and 50 per cent. pulverized white metal. When the powders are well intermixed about 10 per cent. of tannic acid is added, and the whole poured into hot glue and well stirred; a tough, sticky cement insoluble in water results, from which any glue or tannic acid present in excess can be removed by washing in hot water; a mouldable paste is thus obtained, which is pressed into the required shape and dried in the open air for some days, finally at about 250° F. for some hours. The rings, etc., thus prepared are as hard as any real metal, and when polished possess a bright metallic luster; for steam or hydraulic packings they should be prepared from the first mixture and subsequently boiled with tallow, so as to fill up the pores completely; the second composition, containing graphite, must be used without oil or water, being self-lubricant; better anti-frictional results are said to be obtained with such bearings than with ordinary oiled pillow blocks.

MANUFACTURE OF OIL GAS.

By JOHN LAING, F.I.C., etc.

THERE are three convenient methods by which mineral oil can be readily decomposed, viz., by repeated distillation into self; by radiant heat; and by distilling under pressure. In the system which I now bring before your notice for the manufacture of oil gas, I employ a combination of these three methods working in harmony together. Mineral oil gas making is nothing more than the "cracking" operation carried on to extreme. The apparatus consists of an oil still charged with a quantity of oil consistent with the number of cubic feet of gas it is desired to be made. This oil is vaporized by heat, either direct from a furnace for itself or by using the surplus heat from coal retorts, where they are in use. The oil vapors, as they leave the still, pass into a condenser so arranged that the more condensable portion on being liquefied returns immediately to the still for *redistillation* and



IMPROVED OIL GAS APPARATUS

condensation; the lighter portion passes over and down into a superheater, and then, coming into close contact with the *radiant heat* found there, is further decomposed and rendered into permanent gas of very high illuminating value. The back *pressure* on the still, from the gas holders, raises the boiling point of the oil in the still, and thus assists in its decomposition.

Between the still and the condenser I place an arrangement which acts as a water trap, so that should any water happen to get into the still with the oil, it will be removed without any trouble or fear of accident. If this water trap were not employed, then the steam from the still would condense in the condenser overhead, and this water, returning to the still (which is now at a higher temperature), would suddenly burst into steam, and might prove dangerous

This trap catches all the condensed material from the condenser, and should water be present it will fall to the bottom, beause it is heavier than oil; the overflow of oil from the surface returns to the still perfectly free from water, and during the remainder of the distillation there is no possibility of further trouble or anxiety on account of water in the still. This trap is fitted with a cock at bottom, and when you turn it on and find oil, you may rest assured that no water is present to be dealt with. Sometimes it happens that water is present in the oil tanks from which the oil is barreled, and if the tank is well run down, some water may have got into the barrels along with the oil unperceived. In this way water may find its way into a still when being charged from the barrels or tank, but with the arrangement I have here mentioned no harm can result from its presence.

In the form of superheater I am using at present I have a number of disks with holes punched through one half of its surface, and the edges of the disks are vandyked or nicked. These disks are fitted on to an iron rod at regular intervals from each other; the end disk has its holes downward, the next one has its holes upward, and so on to the end, thus giving the gas a zigzag travel, and making it come in closer contact with the radiant heat in the superheater. My reason for giving the gas this zigzag travel is to insure a uniform quality of gas being made. If you merely pass the gas through an empty superheater direct, then that portion of it which is nearest the sides of the vessel is decomposed the most; the central portion is of a heavier nature, and I am strongly of opinion that this mechanical mixture of the molecules (if I may use such an expression) is one great cause why some makes of oil gas smoke so badly on being consumed in the burners. If the hydrocarbon molecules are of a uniform character, then you will have a gas which will give satisfactory results on being consumed. I am quite aware that a proper size of burner should be employed for consuming very rich gases, but what I mean to convey is that using two makes of oil gas and consuming them side by side under the same conditions in every respect as to burners, pressure, etc., you will find that the gas which has been the result of uniform decomposition will give more satisfactory results than the gas which is not so uniform in its composition, and being more a mechanical mixture of its component parts than a chemical one. Oil gas of uniform composition blends immediately with coal gas, and I believe has no tendency to layering in large holders, and accordingly you should have no variation of illuminating value from different heights of the gas holder. Some people seem to think that oil gas does not store well, and that it loses a deal of its illuminating power if it has to travel far. Now this is quite a misconception, for really the fact is that if oil gas is properly made, it will store better, and travel better, and stand cold better than coal gas will, for coal gas depends more on condensable vapors for its illuminating power than oil gas does.

The lower temperature at which you can make permanent oil gas, the better results you obtain. You get a higher illuminating gas, less deposit of carbon, and you get a larger quantity of gas from your oil than if you are decomposing your oils at higher temperatures.

By my process all the dirt is left in the still, and in time produces a pitch of first-class quality; this pitch being liquid while hot, is readily run from the still by an arrangement provided for that purpose, and leaves behind practically a clean still ready for the next charge. Before running down the still bottom it should be sampled first, and if the condition is too soft when cold, that indicates that you can yet take more oil from it, and by leaving it longer under heat you will obtain all the more gas and a better pitch. If for any reason you prefer to have coke to pitch, then just carry on the distillation to dryness, and coke will be the residue instead of pitch. The samples which I now send round are pitch and coke from the same oil. The coke is merely the result of continued distilling heat on the pitch. The best prices for this coke range to about 21s. per ton. This pitch has been valued about 37s. per ton, and had it been taken off a little later from the still, and accordingly been harder, its price would have been higher by a few shillings per ton.

It takes a higher temperature to produce coke, and I prefer to work to pitch for several reasons, viz.:

1. It is not so hurtful to the plant.
2. If you are using a furnace instead of surplus heat from coal retorts, then it takes less fuel, and thus is cheaper to make.
3. It saves a deal of cleaning of stills.

4. It can be stored anywhere and for any length of time without deterioration.

5. It is of higher commercial value.

If you take a red hot still and trickle in slowly say one gallon of oil, and allow the vapors to escape through a sealed condenser of three inches water, you will have a larger amount of coke formed than if you distilled down the same quantity of oil from a charged still with oil under the same conditions. You will thus see that the quantity of pitch obtained by my method of oil gas manufacture is less in proportion to the amount of coke formed by other high temperature processes. Coke is a worse conductor of heat than pitch is by a long degree. It is no uncommon thing to see a still bottom bright red hot with a layer of coke at the bottom and several inches of pitch on its upper surface, and yet the pitch was not strongly giving off vapors.

I may here mention that I have arranged a special pitch cock which will save a deal of trouble by its being easily kept free from plugging up. In the ordinary cocks at present in use, the box or hole in the plug of the cock often retains some of the pitch, and as it cannot escape when the barrel is turned off, it remains and hardens there, and, before another run down can be made, time must be allowed for the hot pitch behind the cock to melt out the plug in the cock barrel. This is sometimes rather difficult to get over, and a steam jet has to play on it for some time before it will clear. To get over all this I got a cock specially made with a "pap" cast on the one side of it; a hole was bored through into this plug box, so that when the plug was turned off a hot wire can easily be passed into the hole and all the pitch cleared out. A screw plug fits into this hole. It might, perhaps, even be further improved by having a "pap" cast on both sides and a hole in it so that a hot wire could pass right through and through, and thus clear the cock with the greatest ease. This method is extremely simple and most effective, and far better than the present system of running a red hot rod up the pipe in line with the cock and melting out the plug. Sometimes the obstruction gives way with a burst, and there is great danger of the person so operating being seriously scalded with the hot pitch from behind coming quicker than he can get the rod removed.

In other processes for oil gas making the oil is injected or run in a stream into the heated retorts or stills; in this way the oil is at once flashed into vapor. What has been rendered permanent goes to the holders, and what condenses again into oil is returned to the still. By this method you obtain an immediate deposit of coke which goes on increasing in thickness as long the feed continues to supply the oil. As this coke deposit increases you must have more heat to enter your still so as to vaporize your oil, and I rather fear that this coke acting as a foreign body in the still will soon set up inflammation and burn it through. By my method I never require a higher temperature than a very little over the distilling point of the oil in use.

If you prefer to use a large size still, then you may work on a large body of oil and distill down as many inches as you require, then draw off the heat by opening the damper to the chimney, and leave the still and its contents as it is till next making time. Nothing leaves the still but vapors, the condensable portion of which continuously washes down the condenser coil and other pipes connected to the still, and keeps them clean and free from deposit, all the dirt remains in the still, and according as the oil you use is crude or partly refined, so you have a greater or less amount of pitch formed in the still. At present I prefer to use the 0·840 or 0·865 unwashed home oils, as the gas from them requires no lime or other purifying treatment. If you use an oil too near the crude state, it would be the better to pass the gas made through the purifiers to remove all traces of sulphur and ammoniacal compounds which are apt to be present at that stage.

Where oil gas is being consumed, it should be burnt in a smaller size burner than that used for ordinary low-power coal gas. You should have a burner which will just prevent smoking. If you use burners much below this point, you get a very much poorer light, owing to the cooling of the flame.

I understand it has been shown that a Bray No. 0, showing 50 candles for 5 cubic feet burnt and giving a good smokeless flame, if the same gas, under the same conditions, was burnt in a No. 000 burner, would show a loss of 35 candles for the same amount of gas consumed.

I find a burner passing 1¾ feet per hour will answer very well for general requirements. By my arrangement large or small works are equally served and no duplicating of plant is necessary for large works; you only require to have a larger or smaller still and condenser in proportion consistent with the amount of gas required. Any kind or quality of oil can be employed with absolute confidence. No skilled labor is required. Keeping up a distilling temperature is all that is necessary to give special attention to. The cost of the plant is not great. I would venture to say that a plant capable of yielding 20,000 cubic feet of oil gas for 24 hours should cost within £100, and such a plant could be fitted up on a ground space of not more than 8 feet square.

There is nothing to get out of order, there being no mechanical parts requiring attention. The whole thing works automatically.

The attendant never requires to soil his person or dress as in a coal gasworks, and the atmosphere is not polluted with offensive smells from lime purifiers, etc. By arranging a "T" piece outlet on the still, provided with cocks at A and B, you can have a very useful combination of still suitable for gas making and oil refining combined. Suppose you have an oil which contains some light material you do not wish to retain, you can readily convert that portion of it into illuminating gas in the manner described, then by shutting off the cock at A and opening B you can convey the remaining vapors of the heavier remaining oil to an ordinary worm condenser and there run them off in the usual way into receiving tanks, at the same time shutting off the heat going to the superheater, as it would not be required. Should such a combination be desired, it would be well to have provision made for a furnace to assist the surplus heat from the coal retorts (if such heat is being utilized), because a smarter heat is better for distilling oil than for gas making; for the reason that if your oil vapors are kept too long in the still in contact with the radiant heat found there, you will have your viscosity greatly ruined, and an oil of lighter specific gravity the result. The smarter heat quickly vaporizes the oil, and accordingly the vapors are less time under heat in the still. The lower temperature at which you distill mineral oils will yield you the heaviest qualities and the greatest viscosity obtainable from such oils. As to the cost of production of oil gas, I would just say that if you are using the surplus heat from coal retorts alone for your oil gas plant, then the cost of the oil gas is practically the cost of the oil you are using. It is not my intention here to enter upon the subject of advantages claimed for oil gas. They are well known and generally accepted.

It may be stated generally that one gallon of mineral oil will yield, off or on, about 100 cubic feet of oil gas with an enriching power of not less than 90 candles, if properly made.

Suppose you are using a poor splint coal yielding an 18 candle gas, then by using five parts of this to one part of oil gas, you would obtain a gas of 30 candle power. It is a very simple matter to arrange for a gas of almost any candle power, by merely adding a greater or less proportion of oil gas to your poor coal gas. Oil gas can be burnt by itself with great acceptance, provided you use suitable burners.

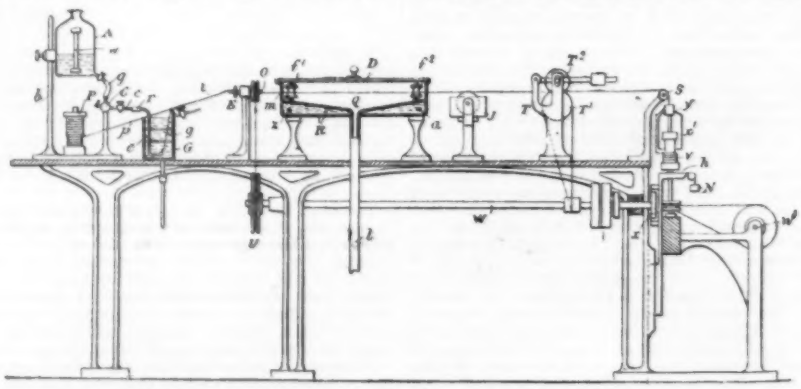
In conclusion, I would strongly recommend that all gas companies should have an oil gas plant in reserve, at least if not in actual use, for should they run short of coal, through miners' strikes or other causes, they can yet prevent, in a great measure, having their towns left in total darkness by the timely use of their oil gas plant. The space required for storing an enormous quantity of oil gas, in a latent stage, is not very great.

Note.—Some gas managers prefer to use a proportion of shale mixed with their coal in the retorts, so as to get the benefit of the high illuminating power from the oil gas made from the shale. Judging from my experience with oils, I would be inclined to say that they do not get the full value of this shale oil as an enriching agent, for a large quantity of its vapors will not have been rendered permanent, and I think they will find considerable quantities of oil condensed into the "drips" or "siphons" or run away with the tar.

P. S.—Since reading the above paper I have made an alteration in my apparatus, by interposing a tank between the return pipe from the coil condenser and the superheater, in order to trap any excess of condensable vapors which, from some cause, should pass over from the coil condenser. Any oil in this tank finds its way back to the still again by a pipe connected by a siphon bend near the bottom of the tank, and opening into the still. The siphon bend remains full of oil, and acts as a seal to the vapors from the still escaping by that opening into the still. Some oils have a tendency to froth or boil over, but with this arrangement any oil which should at any time get over from the condenser would immediately return to the still. Near the top of this tank is an offset pipe, which connects with the superheater, so that gases only are passed through the superheater, and in this way a regular and decomposing temperature is maintained on the superheater and risk of oil getting into the equalizer avoided.—*Jour. Soc. Chem. Industry.*

IMPROVEMENTS IN MACHINERY FOR PRODUCING ARTIFICIAL SILK.

A SOLUTION mainly composed of nitrocellulose is made to flow from small orifices into a liquid, such as water, turpentine, etc., and is drawn out into a fine thread. To produce such a thread from a 5 per cent. solution of nitrocellulose is a comparatively easy matter, but when, in order to obtain stronger threads, the nitrocellulose in solution is raised to 10 per cent., the solution becomes so thick that the production of a thread requires a pressure of several atmospheres to make it flow through fine orifices. The inventor gets over the difficulty by treating a strong nitrocellulose solution with sulphuric or other mineral acid. As an example, to a 20 per cent. solution of nitrocellulose in wood spirit or ether, 1-2 parts of sulphuric acid (66° B.) are added, and heat is applied. A compact precipitate, redissolving on shaking, is produced, and the solution is then much clearer and more mobile than before. The machine for manufacturing the threads is constructed as follows: The reservoir, A, which contains the solution, is provided with a gauge glass, *w*, and can be adjusted higher or lower on the support, *b*. The reservoir is also connected by a rubber tube, *g*, to a pipe, C. This pipe, C, has a number of outlets, connected by a number of rubber tubes, *r*, to a corresponding number of S-shaped glass tubes, *e*. The upper bend hooks over one side of a trough, G, the lower bend is close to the bottom of this trough, and the bent-up end is made to terminate in a narrow aperture. From this narrow aperture the solution enters the soldifying liquid contained in G, and is then drawn out and extended into threads. Any suitable solidifying liquid may be used, as, for example, turpentine, or water, or petroleum. The glass tubes are kept separate in the trough, G, by loosely inserted glass partitions, which do not impede the circulation of the liquid, but prevent the filaments from becoming entangled, should any filament break. Any number of the filaments, *i*—seven is a suitable number—are, as they form, conducted jointly to guides at E. At E, if desired, a thread or filament, *p*, of any other material, natural or artificial, may be added, for instance, a cotton thread, real silk thread, or others. This additional thread is contained on the spool, P, and is guided from the spool below the tube, C, over the trough, G, to the guide, E. The united filaments, *i*, and the natural filaments, *p*, are now steadily drawn off by the mechanism, T, and then guided through a narrow aperture, *m*, to the drying chamber, Q, which is closed as air tight as possible, and provided with a lid, D. On leaving the drying chamber the filaments reach the denitrating appliance, T. This consists of a roller partly immersed in a denitrating liquid, by preference ammonium sulphide, which removes a portion of the nitro groups and neutralizes any free acid which may adhere to the filaments. By the drawing forward mechanism, T, the filaments are then drawn over the guides, S, to the spinning apparatus, x^1, which may be of any known suitable construction.—*F. Lehner, Zurich.*

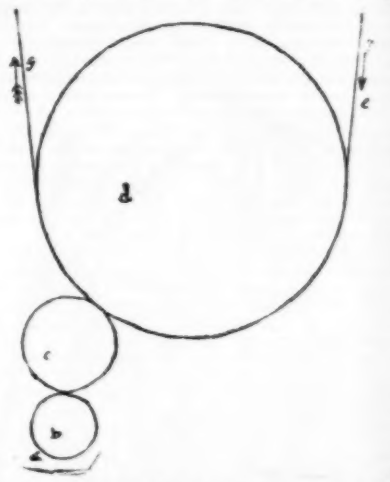


MACHINE FOR PRODUCING ARTIFICIAL SILK.

CALICO PRINTING MACHINERY.

By JOHN WATERSON.

WITH the exception of one or two styles, the whole of the calico that is printed is done on the cylinder printing machine. This is a Scotch invention, brought out about the year 1770-1780, and about 1830 was practically as we find it at the present day. The principle on which the machine works we will now explain by the help of the diagram. The cloth to be printed, *c*, passes around the bowl of the machine in the direction shown by the arrows. The bowl, *d*, is lapped with several thicknesses of blanket, in order to provide an elastic but firm bed for the cloth, and one which will press the cloth well into the engraving. The printing color is contained in the color box, *a*, which may be constructed of wood or copper, and the color is supplied to the engraved printing roller, *c*, by means of the furnisher, *b*, which is a wooden roller covered with cloth. The furnisher presses the color into the engraving, as well as smears the surface; the surface color is then removed with a copper-plated steel blade, known as the color doctor. The copper printing roller, charged with color, then comes in contact with the piece to be printed; the latter soaks up part of it and the remainder is transferred on account of the pressure on to the face of the cloth. The cloth then passes on to the next roller, or if it is only a single color pattern, to the drying chests.



The lapping used on the bowl of the machine has a linen warp and woolen weft, ten thicknesses being generally employed. The thickness of the doctor to be used depends upon the character of the engraving on the roller, a thick doctor being used for heavy engraving, such as blotch work, and a rather thinner one for fine engraving, as small sprig or flower patterns. The average thickness of the doctors employed is about 28 on the standard wire guage. The furnishers can be driven either in the same direction or in the reverse direction to that in which the engraved printing roller is traveling. With most of the colors the furnisher is worked in the same direction as the printing roller is going, and generally in such cases a lapped furnisher is placed in the color box; but when pigments or any color liable to stick in the engraving is being printed a brush furnisher is preferable, and it should be driven the opposite way to that in which the copper roller is

revolving. For fine patterns a very soft furnisher should always be used.

In addition to the color doctor, there is another doctor at the other side of the printing roller, the object of which is to remove any lint or "fluff" that may have come off the face of the piece and thus prevent it being carried into the color box. Lint soon finds its way to the color doctor and lifts it, with the result that the piece is streaked until the lint is removed.

Many colors are very liable to froth in the box, and this is particularly liable to occur if the machine is run too quickly. If the machine is run at too great a speed, the cloth has not time to take the color from out of the engraving, and is, consequently, badly printed.

A to and fro motion is always given to the doctors by various mechanical devices, such as by level wheels and cranks, eccentrics, or by cam and lever, the object being to cause the doctor to wear evenly. The doctor, if fixed in its position relative to the engraved roller, would be worn only by those parts of the roller in contact with it, viz., the plain parts and the edges of the engraved parts, hence the edge would soon become uneven. By giving a to and fro motion to the doctor, this is, to a considerable extent, avoided.

Formerly printing machines were driven by underground shafting, provided with clutches for various speeds, a choice of three being general. Now each machine is driven independently by means of a separate steam engine, and this is found more convenient and economical on account of the irregular service required of the motive power.

THE LEAD INDUSTRIES IN GREAT BRITAIN.

THE committee appointed April, 1893, were directed by the Secretary of State to inquire (1) into the conditions under which lead smelting, the working of blue lead and the production of white, red, and yellow lead and litharge are conducted, with the object of diminishing any proved ill effects on the health of the workpeople engaged therein; (2) as to whether the special rules which already exist for the manufacture of white lead are sufficient; and (3) to suggest any precautions for the protection of life and health. They were further directed to inquire into the tinning and enameling of iron hollowware and plates, the death of Harriet Walters, and the use of red lead in electric accumulator works.

The committee visited 46 works in England, Scotland, and Wales, and examined 184 witnesses.

I.—WHITE LEAD.

There are three processes by which white lead is produced: (*a*) the old Dutch process; (*b*) the chamber process; (*c*) precipitation. The first is the commonest, and the committee saw only three of the second and one of the third.

In the old *Dutch process* the desilverized metallic lead is melted and cast, sometimes into gratings, sometimes into thin oblong plates, with two holes and a central rib. In most works the casting is done by hand, women being often employed; in some, however, by machinery, which not only casts the lead, but delivers it at a convenient place some distance off. In the latter case, the only hand labor involved consists in putting the pig lead into the melting pot and regulating the flow of the molten lead. The gratings are next put into stacks, large cubical places built of bricks, the floor of which is just covered with a layer of tan. On this are arranged, as closely as possible, stoneware pots filled with dilute acetic acid, and on the top of these are placed four or five gratings, one on top of the other. Boards are then laid on the top of the gratings so as to form a new floor, on which tan, pots, and gratings are laid in the same order as before, and this is in its turn covered in the same way, and so on until the stack is full, as many as ten or more layers going into one stack. The filling is done through a vertical opening in one of the sides of the stack, which is closed by boards as the stack fills up. As the floors rise the various materials must be lifted up to them. This is generally done by women, who have to carry on their heads from 30 to 50 pounds of lead at a time up ladders 10 to 15 feet high. In some works the material is passed from hand to hand up stages or lifted by hoists worked by machinery. When full it is covered in, a ventilating shaft in each corner is provided, and the stack is then left to itself for from 10 to 15 weeks. The tan soon heats, evolves carbonic acid, and volatilizes the acetic acid. An interaction then takes place between the lead, acetic acid, carbonic acid, and the oxygen of the air, leading to the ultimate production of amorphous basic carbonate of lead or white lead. The action goes on until all the lead is corroded, or until there is no more carbonic acid evolved, or until all the acetic acid is volatilized. There is always some acetate of lead left in the final product. Then the stack is opened, and the white lead, which retains the shape of the lead grating, is taken out. It used to be taken out dry, but according to present regulations it is wetted first, to stop dust flying about. It is then carried in trays, generally by women, to corrugated rollers, over which passes a constant stream of water, and tipped down in front of them to be crushed, so as to detach any metallic lead left uncorroded. Before this is done the crates are either dipped in water or well watered to prevent dust rising, and even then some dust comes off. The crushed mass next passes into a shallow tank, with a perforated bottom, in which it is raked about to separate the pieces of blue lead from the white lead, which latter passes away with the current of water to grinding mills. Here it is ground up and then run into a series of tanks (washbecks) to settle. The water is then drawn off, and the white lead is removed, put into earthenware or copper pans, and placed in drying stoves. In some works the wet mud is run through a filter press, and the press cake put into the stove. The pressing not only greatly reduces the time necessary for drying, but renders the whole process more cleanly and free from dust. When thoroughly dry, which takes from three to five days, the pans are taken from the ovens by hand labor, and the white lead is either packed directly into casks or thrown into bins for subsequent conversion into paint. The above operations give rise to a good deal of dust, and in order to obviate it mechanical drying stoves have been invented for carrying in the wet white lead and discharging the dry into barrels by machinery. No perfectly satisfactory mechanical stove has yet been devised; they are also very costly.

The *Chamber process* is also one of corrosion, but a chamber is used instead of the stack, and the strips of lead are hung saddle fashion on sets of parallel bars. The chamber is heated by steam to a regulated temperature and the carbonic acid is supplied from burning charcoal by a flue, while pans of acetic acid are laid on the floor. The corrosion in this process only takes four or five weeks. The subsequent treatment is the same as the old Dutch process.

The quantity of white lead produced by *precipitation* is as yet very small.

Effects of Lead.—If lead, in however small quantities, enters the system, symptoms are developed, the most frequent of which is colic. Nearly all of those who work in factories on lead or its compounds look pale and anæmic and show a blue line on the gums. Lead palsy occasionally affects their hands. There is also a very sudden and fatal form of lead poisoning, most frequently met with in young women, which begins with headache followed by convulsions and unconsciousness. Death often occurs in three days, and in some cases of recovery from convulsions total blindness remains.

There is some doubt as to how the poison enters the system. The committee think (*a*) that it may be absorbed through the pores, particularly during perspiration or where there is friction between the skin and the clothing; (*b*) that it may get into the stomach by touching food with dirty hands; (*c*) but that the most usual manner is by inhaling the dust. Some of this dissolves in the mouth and is swallowed, and some gets to the lungs and is absorbed by the blood.

Rules.—The existing special rules under the Factory and Workshops Act, 1891, for white lead works are then cited, and approved so far as they go.

Danger of Working.—The committee find that the dangerous parts of the *old Dutch process* are: (1) the stripping of stacks; (2) the rollers; (3) the washbecks; but (4) chiefly in the stoves and packing. The committee find that (*a*) women are more liable to lead poisoning than men, and (*b*) young girls than full grown women.

Recommendations.—Lead was found as acetate and sub-acetate in the washbecks of certain works, and in one the quantity was large. The workers have to plunge their hands in these washbecks. The committee enjoin manufacturers either to treat the washwater so as to separate the lead or to discontinue letting the workers put their hands in the water.

The committee report that the special rules issued in 1892, as to cleanliness, medical inspection, and sufficiency of good food, have been of great benefit. Certain firms give their workers some food either before beginning work, at 11 o'clock, or at the dinner hour, and the committee trust that this will become universal in the trade. They recommend also that a new rule be added, whereby no female should be employed without examination, and a medical certificate that she is of the required age and fit for the employment; and further that no worker, after absence through illness, should be re-employed without a medical certificate that he or she has recovered. Also that no girl under 20 be employed in the old Dutch process, and that every woman be compelled to produce a certificate either of birth or baptism before she can be employed. Also that the stacks, rollers, washbecks, stoves, and packing be worked in future by adult male labor alone. The further use of mechanical appliances is also strongly urged, and recommendations as to clothing are made. In regard to the inhalation of lead dust, reference is made to Dr. Dupre's experiments, and the necessity of enforcing the use of respirators is recognized, of which the best form is considered to be a cambric bag made to fit over the nose. Workers are urged to co-operate with their employers in enforcing the regulations. No packing or storing of dry white lead is to be carried on except under a hood connected with a fan or other device for creating a draught, whereby the dust shall be carried away. A dining room must be provided, and no one is to take any food elsewhere in the works. Every stack is to be fitted with an adequate supply of water for damping the contents of the stack previous to stripping it, and water is not to be fetched from a distance. No stack is to be stripped before it is "mature."

II.—SULPHATE OF LEAD.

This is manufactured directly from galena by throwing small shovelfuls into a coke furnace highly heated. The galena is volatilized and oxidized directly into sulphate. This is collected in chambers and then washed and dried much as in the case of white lead. There is not much danger in this process, as the sulphate of lead is less poisonous than the carbonate, but it does not possess either the color or the covering power of the latter. Mr. A. P. Laurie has recommended an experimental trial of white lead substitutes, but the committee think it better left to be settled by competition in the open market. The price of sulphate is from £3 to £4 a ton under that of white lead.

III.—SUBSTITUTES FOR WHITE LEAD.

Several compounds have been mentioned to the committee as being equal to white lead. One of these is oxide of zinc. This has been used with success for internal work, but it does not bear exposure to heat, cold, and rain, nor does it possess the covering power of white lead. Moreover it is more expensive. All the other substitutes proposed have also proved to be in some respects inferior.

The committee have come to the conclusion that there is at present no substitute for white lead made by the old Dutch process. Also that this process may be rendered sufficiently free from danger to warrant its continuance with proper and efficient safeguards.

IV.—RED AND ORANGE LEADS.

Orange lead is simply white lead heated in furnaces. Red lead works are frequently in connection with white lead works and call for similar special rules.

Red lead proper is blue lead oxidized at a low temperature. Pig lead is placed in a furnace, a large surface of which is exposed to heat and air. The metal when melted is not more than an inch or two thick on the bed. It is raked about by men through a door from which lead fumes escape. These are caught by a draught chimney and carried away. The safety of the furnace men thus depends on the efficiency of these chimneys. The lead is first oxidized to massicot, and in this state is raked out preliminary to a further treatment which is not described.

The committee recommend that instead of raking the massicot on to the floor, it should be shoveled into wagons, and that all packing should be forbidden in the place of making, but be carried on elsewhere under a hood with an effective draught. This also applies to orange lead. Baths and lavatories are enjoined, as well as medical inspection. Special drinks are also ordered.

V.—LITHARGE.

No recommendations are made with regard to litharge.

VI.—COLORS.

In regard to the manufacture of Milan red, vermilionette, Persian red, etc., the committee consider that the present rules for paint and color works will suffice, if respirators be made compulsory whenever dust is generated, and baths be provided in addition to the ordinary washing arrangements. No young male or female, however, is to be employed in such manufactures.

VII.—LEAD SMELTING.

The ore is treated in a furnace and the metal extracted from it. The same precautions as to carrying off the fumes escaping from the door are used as in the case of red lead.

The committee recommend that only adult male labor shall be employed, with precautions as to respirators, clothing, length of work, and washing accommodation.

VIII.—BLUE LEAD.

No recommendations are made in the case of working and desilverizing metallic lead.

In regard to pipe and sheet making, inspectors of factories are enjoined to take note of and report any cases of poisoning, which are stated to be rare.

Bullet and shot making are considered safe.

Plumbing and house painting are not included in the reference to the committee.

IX.—YELLOW LEAD.

This color is made by mixing bichromate of sodium or potassium with lead salts. Reference is made to Dr. Scott's evidence, and the enforcement of the provisions he advocates is recommended. These are ventilation, use of respirators, and certain drinks, with abundant washing accommodation. No ill effects have been traced to the use of articles dyed or painted with yellow lead.

X.—ELECTRIC ACCUMULATOR WORKS.

Red lead or litharge, previously damped with dilute sulphuric acid, is rubbed on to both sides of embossed or perforated leaden plates, so as to fill the interstices and produce an even surface. One man mixes the dry red lead and sulphuric acid, while others rub the mud into the plates. Gloves are used, but do not last long. Another method is to fit a piece of lead with projections into a mould and push in red lead enough to fill up the spaces. When pushed in tightly the whole readily comes away from the mould, which can be then used again. The red lead mud is also made into square cakes. In all these processes the hands of the workers come in frequent contact with the material, and in some cases gloves are not worn.

The compulsory use and inspection of gloves is recommended, with ample washing accommodation. The increased use of machinery is also considered desirable.

XI.—ENAMELING OF IRON PLATES.

The iron plate, having been cleaned, is first smeared with a little gum and water, and then a fine powder, which may contain up to 25 per cent. of lead, is sifted over it. The plate is then heated in a furnace until the powder melts, forming the first coating of enamel. Another way is to put on the powder previously wetted with a ladle. The next process, known as "swilling," is to brush color, which nearly always contains lead, carefully over the plates. This is gone over with finer and finer brushes to secure an even surface, and the plate is then dried. Up to this point not much danger attaches to the industry, but it is in the next operation that most of the danger lies. The workers (women) place a stencil on the plate and rub off the exposed color with a nail brush. This comes off as a thick dust, and although they work on perforated tables, some dust inhaled. When the upper layer of color is rubbed through and the pattern appears clear and sharp the plate is again fired. The process may be repeated several times, according to the number of colors required. The lead used in the enamels is chiefly red lead, and the manufacture is a trade secret.

The existing special rules under the Factory and Workshop Act, 1891, for enameled iron plate works are then cited and approved, so far as they go.

The committee find that severe and sometimes fatal illness results to the workers in the stenciling process.

Frequent medical inspection is insisted on, no girl under 20 is to be employed, and no female without previous examination and medical certificate that she is of the required age and fit for the work, as in the case of white lead works. Enameling firms are also recommended to give each female worker half a pint of milk and a biscuit before beginning work. The perforated bench is also to be boxed in below and supplied with a fan to draw down the dust. A separate dining room is also to be provided.

XII.—THE DEATH OF HARRIET WALTERS.

This girl, aged 16, was employed in an enameling works at Bilston, and the circumstances attending her death are detailed. She died of lead poisoning, a typical case. The committee criticise the medical evidence.

XIII.—THE TINNING AND ENAMELING OF IRON HOLLOWWARE.

This industry of preparing kettles, saucepans, frying pans, etc., is largely carried on at Wolverhampton, Bilston, Dudley and the neighborhood. The article in

the rough, previously cleaned with dilute hydrochloric acid and chloride of zinc, is dipped into a "pit" containing a mixture of melted tin and lead in varying proportions, according to the quality of the goods. The leading firms use no lead for culinary utensils, but only when the article is to be japanned also. Such vessels are generally slop pails, coal scuttles, baths, etc.

The committee commends the suggestion of H. M. Inspector of Factories that the use of lead and arsenic in the enameling and tinning of culinary utensils should be absolutely prohibited.

Washing accommodation, with compulsory use thereof, and prohibition of eating, except in a specially provided room, are to be extended to this industry.

XIV.—REMARKS APPLICABLE TO ALL THE FOREGOING TRADES.

The duty of employers and workers is discussed in relation to the existing and proposed rules, and penalties for contravention are proposed; while the duty of reporting lead poisoning is placed on the same footing as that of reporting accidents. A summary of all the foregoing recommendations and suggestions is given, and after some remarks on the probable effect of these upon the lead industries, the committee record their conviction that lead and all its compounds are more or less poisonous and that the use of each or all of them is attended by danger.

VARNISHING GLASS.

By NELSON K. CHERRILL.

IN a recent number of the *Electrician* it is mentioned that Messrs. Siemens & Halske have recently adopted the system of dipping lamps in a thin semi-transparent varnish to obtain the effect of ground glass. As the writer has had much experience in this class of work, a few notes of the best mode of procedure may be of interest. The application of various modifications to the normal appearance of a lamp by means of varnish, either colored or plain, is by no means a novel expedient, and a similar plan has, I believe, been commonly employed in many places for decorative work.

The most important point in the application of varnish to a lamp is to get it to dry just in the right condition. Most kinds of varnish that will dry "bright" under ordinary circumstances will become "matt" if subjected to a chill, or to the action of damp during the drying, and at the same time many varnishes intended to dry with a "matt" surface, that would represent ground glass, dry "bright," if the conditions of drying are not quite suitable.

The class of varnish best adapted to this kind of work is what is known as photographer's negative varnish. This class of varnish dries almost as hard as the glass itself, and when well applied is very durable. When colored lamps are needed, the varnish should be of a quality to dry "bright," but when the effect of ground glass only is required, the simplest way is to use what is known as "retouching" varnish, which gives a "matt" surface at once. In default of this, the ordinary negative varnish can be easily modified to give the desired surface by the addition of a little weaker alcohol, which almost always has the desired effect; but if there is any difficulty, a little common resin, which chills very easily in drying, may be added to the varnish.

As to the mode of applying the varnish to the lamps, the best plan is to hang them on a frame by their contacts, so that a current can be passed through them during the operation. The lamps should be well washed in warm water, in which there has been dissolved a liberal dose of soda. A thorough rinse with fresh cold water should be given, and the bulbs should then be carefully wiped quite dry with clean linen rags. If the work is to be very nicely done, the operator who hangs up the lamps on the screen should have on linen gloves, as finger marks on the glass are apt to show when the whole process is finished. The varnish is poured into an upright glass vessel large enough to contain the lamp. A common drinking glass is as good as anything, if large enough to admit the lamp. In pouring out the varnish, care should be taken not to disturb any sediment which may be at the bottom, and if not quite clear it should be filtered, as it is of the greatest importance to avoid any small floating particles, which would cause spots or streaks on the finished surface.

All being ready, if the varnish is to dry bright, *i. e.*, for colored lamps, etc., switch on the current to the lamp for a few moments, so as to render it slightly warm. Then turn it off, and taking the glass of varnish in the left hand, raise it under the lamp until the whole globe is immersed. If the lamp is in any kind of rigid fitting, it will be very easy to immerse it, but if it is merely hung on a couple of wires, it will require the aid of a little instrument, consisting of a forked piece of wood, to push the globe down into the varnish. As soon as the varnish entirely covers the globe, lower the glass with one steady movement, so that the draining off the superfluous varnish shall be commenced in one even wave all over the globe. Any hesitation or pausing in the motion of the glass will be almost sure to cause a line on the finished lamp.

As soon as the tumbler of varnish is quite clear from the lamp, turn on the current again, and leave it running, while several more lamps are being done. When about twelve lamps have been varnished, the first will be ready to come off. But a little care must be taken till the lamp is quite cold, as some varnishes will finger mark readily at this stage. If the varnish is to dry "matt," the lamp should be plunged quite cold, and no current should be put into the lamp till the varnish has chilled all over, then a little warmth will aid the drying, and will also harden the varnish.—Almost any color can be given to the varnish by the simple use of Judson's dyes, which will readily mix with the varnish and impart their characteristic tints.

Blue is the most difficult color to arrive at satisfactorily, as the dye does not seem to blend so well with the varnish as the other colors, and, besides, the color is spoilt by the yellow tone of the light. To avoid this part of the difficulty, the lamps which are to be used blue should be run as *hot* as possible, while those for red or yellow colors may be comparatively cool, the yellow especially so.

It goes without saying that all the testing of the lamps must be finished before the varnishing is commenced.

A pleasing effect is sometimes produced for purely decorative work by using a little dye with the "matt" varnish.

ALEXANDER SIEMENS.

MR. ALEXANDER SIEMENS, whose portrait we publish this week, was born, says *The Electrician*, at Hanover in 1847, and was educated at the Lyceum and Polytechnic College there. In 1867 he came to England, and worked for a short time at the telegraph factory of Messrs. Siemens Brothers, at Woolwich. In the following year he went to Berlin to study at the university, and remained there until 1870, with the exception of filling a temporary engagement, during which he assisted in constructing the Indo-European telegraph line from the Persian frontier to Teheran and in laying the Black Sea cables at Kertch and from Sukhum Kale to Sotcha. He was next called upon to serve his country in the Franco-German war, and was present at the siege of Metz, and afterward, under Prince Frederick Charles, joined in the operations against Orleans. He was wounded at the battle of Beaune la Rolande, and for his distinguished services in the field received the Iron Cross.

At the conclusion of the war Mr. Siemens was able to continue his scientific studies, and coming to England became a pupil of the late Sir William Siemens. In 1873–74 he was conducting experiments for Sir William, at Birmingham, with a rotary furnace to produce wrought iron and steel direct from the ore. In 1875 Mr. Siemens joined the cable ship Faraday and took part in several cable laying and repairing expeditions. While the ship was stationed at Halifax, N. S., he built some blast furnaces at Londonderry, N. S., for the Steel Company of Canada, and superintended the erection of a rotary furnace at Pittsburg, Pa. Returning to England in 1877, he was employed in erecting regenerative gas furnaces for various purposes in different parts of England, among them being the first continuous working tank glass furnace erected in this country. In 1879 he became actively engaged in electrical work for Messrs. Siemens Brothers, and had to

ALEXANDER SIEMENS.

do with some of the first electric light installations, such as those at the Albert Hall, the British Museum, the Albert Docks and the Blackpool Promenade. He also laid down an electric light plant at Godalming, the first town in England to so light all its thoroughfares and supply current to private consumers.

Mr. Alexander Siemens became a director of Siemens Brothers & Co. some time ago, and is now the only director residing permanently in England. In 1892 he contributed a paper to section G of the British Association at Edinburgh, on "Electric Locomotives on the City and South London Railway." He has been for many years a member of the Institution of Electrical Engineers, to which body he has contributed several papers of great interest to the profession, the most recent being that read on February 11, 1892, upon "Some Experimental Investigations of Alternate Currents." He was elected a vice president of the Institution four years ago, and is president for the year 1894.

STORAGE BATTERY TRACTION AT WASHINGTON, D. C.*

By GEORGE C. MAYNARD.

STORAGE batteries have been weighed in the balance and found—*too heavy*. An honest man held the scales. Geo. W. Pearson is one of the best all-round street railway men in the United States. For nine years he has been president and active manager of the Metropolitan Railway, in Washington, D. C. During that period the necessity and the possibility of procuring a substitute for horse power for the propulsion of street cars has been one of the most important and pressing subjects he has had to consider, and he has given it the most careful and thorough study. Every known method has been investigated. These investigations led Mr. Pearson to a belief in the truth which everybody realizes and all disinterested persons admit, that the ideal motor is one which will make every car independent of all the others.

The Metropolitan Railroad (not counting several branches) is a double track road five and one-half miles long. It begins on the hills above Georgetown and ends in the eastern section of the city, a mile beyond the capitol. It runs through the principal business and residence sections of the city and passes the capitol and eight of the principal government buildings. The travel on the line is irregular, and at times exceedingly heavy. There is not a hundred feet of level track in the whole road. The grades range from two and one-half to five per cent., and there are forty-two curves, many of them very sharp. The sharpest curves are on the heaviest grades.

The use of a cable under such conditions was manifestly impracticable; the trolley system was prohibited by public opinion and a law of Congress; steam was out of the question; the proposition to use compressed air was an intangible scheme. On March 5, 1889, a special act of Congress declared that the use of horses should cease two years thereafter.

These facts pointed to storage batteries as most likely to furnish available power. Out of ten chaotic years of bitter contests and wasteful litigation over the rights of rival claimants to the invention, there came fair prospect of commercial utility backed by strong assurances from men of good judgment and sincere purpose. Some of the most competent electrical engineers in the country unhesitatingly declared their conviction that street railways could be successfully and economically operated by this system.

In the summer of 1889 Mr. Pearson and his associates determined not to add one more to the long list of trifling experiments, but to operate their road with storage battery cars if it were possible. At the outset they engaged the services of the well known electrical engineer, Mr. C. O. Mailloux, of New York, who had made a special study of accumulators ever since their introduction, to design a suitable plant and superintend its construction and operation. With him came Mr. F. H. Chamberlain, a practical electrical expert who had had a long and varied experience in work of this character. He has had charge of the Metropolitan power house and all the details of the work during the entire time it has been going on.

In the course of four months after the undertaking was started the first car was put on the road. Experimental trips were made at night after the day's traffic was done. With a fair load of the company's officers and directors a speed of 15 miles an hour over the whole line was attained and the prospects of success brightened. Additional cars were equipped, and, early in 1890, several were put on the road for regular service, sandwiched between horse cars and running at a uniform rate not exceeding six miles an hour. The fact that they were limited to this slow speed when they could easily go much faster was a trial to the ambitious motormen, who were disposed to regard their position as quite superior to that of the car horse drivers. Passengers patronized the new cars and the public watched their progress with much interest. Popular opinion turned in their favor, and for a while there was frequent expression of the opinion that the problem of rapid transit in large cities was solved. Still the months ran on into years and the horse cars were not displaced. Then there began to be surmises that the Metropolitan Company was only trying to gain time by making a show of changing its system, and did not really intend to make the use of storage battery motors permanent, even if the scheme proved feasible. As time went on the motors began to show signs of weakness, being frequently seen slowly laboring up the grades with a long line of horse cars behind them, and now and then blocking the road with a flat refusal to move another foot. In such cases their excessive weight precluding the possibility of removing them from the rails, the horse cars were jumped around them until relief could be obtained, when the proud-spirited motorman was compelled to resign his command to a plebeian driver, and four of the strongest horses from the stable would ignominiously drag the lumbering old ark back to the seclusion of the power house. As many as four cars were stalled at one time. But this was not altogether discouraging, for while the result of the trial of the first storage battery was not successful, the respective promoters of nearly a dozen other schemes stood ready to guarantee that their batteries would do the work. Every one of these was given an opportunity to demonstrate the truth of their claims, and nine different styles of accumulators were tested. The company provided every facility for charging and operating the batteries, and allowed the experts of each company to personally supervise the operations and to show what they could do.

An inspection of the Metropolitan Company's power house and facilities for operating the battery cars clearly evidences the seriousness and determination with which Mr. Pearson undertook the work. The buildings are substantial, spacious structures, erected especially for the work. The boiler house is 50×60 feet and contains three Campbell & Zell's 200 horse power boilers set with Murphy's mechanical stokers and provided with appliances of the most approved and efficient character. The engine and dynamo room is 65×85 feet. There are three Wright tandem compound non-condensing engines of 230 horse power each in place, with foundations laid for a fourth engine of the same size. The principal dynamos are Thomson-Houston 160 kilowatt machines, capable of developing a current of 220 volts and 800 amperes, and a number of auxiliary machines provided with ingenious appliances for coupling them in various combinations afford facilities for supplying any desired current. The station is equipped with an exceedingly complete outfit of the best Weston testing and measuring instruments.

The battery house is 85×122 feet, two stories high. The floors are built of cement, laid on heavy iron supports, and are thoroughly acid proof. The arrangements for convenient and rapid handling of the batteries are most complete. This building faces the street along which the main track runs, while the engine and boiler houses are in the rear. By a loop from the main track the cars are run through the building, stopping on a platform, on each side of which is an elevator operated by two Thomson-Houston 15 horse power motors. The batteries arranged in racks, after being charged in the upper story of the building, are lowered to the side of the car, where the exhausted cells are quickly

* *The Electrical Review*, New York.

drawn out and the fresh ones put in. This equipment affords facilities for handling 180 sets of accumulators, and the building has space for twice that number. The plant in its present condition can easily charge 60 sets of accumulators at one time. In addition to the extensive and substantial character of the buildings above described, an item on the company's cash book of $387,000, expended in constructing the plant and operating the motor cars, substantiates the statement that the company has left nothing undone to work accumulators for all there is in them. Forty cars were built especially for this work, and 15 of them were fully equipped for service. The highest number of cars ever out on the road at one time was 10. At the commencement of the experiments, motors and dynamos, especially designed by Engineer Mailloux, were built for the company, but a little later those made by the Thomson-Houston Company were tried and found more satisfactory. Two 15 horse power motors, weighing 1,600 pounds each, were used on each car. The Baltimore Car Wheel Company's improved storage battery truck added 2,000 pounds, and the total weight of the car thus equipped was six and one-half tons. The horse cars on the Metropolitan line weigh about two tons each.

At first much difficulty was experienced with the regulators, but improvements devised by Messrs. Mailloux and Chamberlain soon remedied this. The arrangements of circuits to secure five distinct rates of speed were as follows:

1. Both batteries in multiple, motor fields and armatures in series.
2. Both batteries in multiple, motor fields in series, armature in multiple.
3. Both batteries in series, motor fields in series, armature in multiple.
4. Both batteries in series, motor fields and armature in multiple.
5. Same as 4, with 5-10 shunt across the fields.

To sum up the elements of the undertaking, the following points are clear. Steam plant perfect; dynamos and accessories, comprising the charging machinery, everything that could be desired; facilities for handling the batteries admirable; cars and their motor equipments of the best; the track newly constructed by the Johnson Company, of 62 pound improved grooved girder steel rail and in excellent order; the best professional skill obtainable; intelligent, skillful and energetic business management—all essential elements to success—and success must have been attained had the performances of the accumulators been equal to the company's expectations and the promoter's promises. As the records stand, failure must be written for every one of them. They started out with hopes and ambitions, but hopes were doomed to disappointment, while ambitions and amperes disappeared together.

The companies whose accumulators were tested will be designated by number.

No. 1.—The car was equipped with 120 cells, weighing 27 pounds each, and the trial lasted about seven months. The longest run made on one charge was 27½ miles. When the cells were new they were given a charge of 100 ampere hours and the discharge was 86 ampere hours, but this creditable performance was not sustained. After being charged and discharged a few times the efficiency fell steadily and rapidly, and after a service of 1,327 miles the cells were entirely exhausted and worthless. This feature of rapid depreciation was experienced with every battery used. In no instance was the electro-motive force allowed to fall below 1·5 volts per cell.

No. 2 was one of the most promising accumulators experimented with. It was furnished and its use superintended in person by one of the best scientific and practical electricians in the country. Ninety-six cells, 32 pounds each, comprised the outfit for a car. It required 250 ampere hours to charge these cells, and, in return, they gave just 43 ampere hours' service, never making more than six and one-half miles run on one charge. At the end of their 365th mile they were dumped into the scrap pile.

No. 3 was another serious disappointment. One set of 96 cells, 33 pounds each, was first procured, and its service proved so satisfactory that the company ordered equipments for 10 additional cars. The latter were failures. The first was charged in 100 ampere hours, discharged in 86 ampere hours and ran 21¼ miles on one charge. The record of the others shows 420 ampere hours' charge and 43 ampere hours' discharge, with a run of only nine and one-half miles. The total service of the best car on which this system was used was 600 miles. After this discouraging experience there came with serene confidence and high hopes, the promoters of

No. 4.—Ninety-six 42 pound cells were used. After carefully and faithfully giving them a charge of 450 ampere hours, the car was put on the road, made a fitful and feeble run of exactly 5,000 feet, and never turned a wheel again. Horses hauled the car home, and the accumulator expert left the city before daybreak.

No. 5.—The staying qualities of this battery were vouched for by business managers and electricians of high character and long experience. There were 112 cells, 42 pounds each in a set. Their record in ampere hours is 100 charge to 86 discharge for the first few trips, after that they fell away rapidly. Twenty-two miles was their longest single run and 3,243 miles ruined them.

No. 6.—The operation of this battery was superintended by two experts representing its manufacturers. After receiving a charge of 250 ampere hours it rewarded its owners by discharging itself in 26 ampere hours, getting the car three miles away from the power house before breaking down. It was never tried again.

No. 7.—One hundred and ten cells, 32 pounds each, ampere hours 100 charge to 86 discharge, longest run 22 miles, total service before breaking down 2,227 miles.

No. 8.—Ninety-six cells, 44½ pounds each, ampere hours charge 100, discharge 86, longest run 22½ miles, total service 4,123 miles.

No. 9.—One hundred and twelve cells, 32 pounds each, ampere hours charge 100, discharge 43, longest run 10½ miles. These batteries failed after running 70 miles.

The best batteries tested did not stand more than 27 days' actual service, and the cost of running the cars by five of the most serviceable batteries ranged from 12½ cents to 37 cents per car mile. The cost of running horse cars on this line is about six cents per car mile.

The causes of failure are numerous and not easy to enumerate. Buckling plates, excessive heating, loosening of active material, short circuiting of cells from various causes, general rapid deterioration of positive plates, sudden and sometimes unaccountable loss of current, destruction of connections by acid, are some of the more marked eccentricities of the accumulators. There is a lingering suspicion that they are safer in the laboratory of a professor of chemistry than on a jolting tram car.

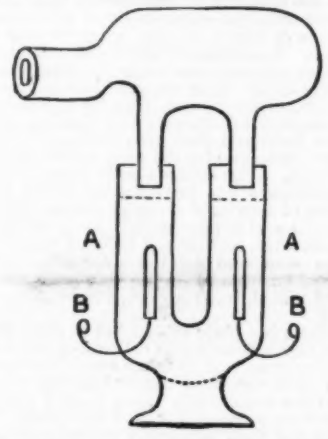
After more than four years of intelligent and persevering effort the undertaking has been suspended. The motionless machinery, the idle cars and valueless batteries, the enormous hole in the company's bank account are full of significance. Every available means to attain success was tried and failed. The experiment has settled many vexed questions, exploded some humbugs and will be of great value to all persons interested in street railroads. It has made it clear that, up to the present time, science and art have not produced a storage battery capable of supplying power to practically operate such roads as the Metropolitan.

Still the result does not justify absolute condemnation of storage batteries for railroad use, nor destroy hope of an independent railway motor. Such a motor is demanded by public need, the inventive genius of the world is challenged to produce it, and there is a growing faith that, somewhere in the conserved forces of the universe, there is a power which shall wipe the usightly and obstructive trolley lines off the face of the earth, shall bury the power-wasting cables in their own grave, and turn the faithful car horse out to the enjoyment of green pastures and well-earned days of rest.

AN ELECTRIC BLOWPIPE.

By H. N. WARREN, Research Analyst.

THE difficulty of manipulating with hydrogen gas in conjunction with oxygen when high temperatures are desired has for a long time past induced experimenters



to substitute for the former coal gas. This agent, although suitable for lime light illumination, is far inferior as regards temperature to the use of pure hydrogen. During the past season the author has had occasion in several instances to test the efficiency of the two mixtures. Several refractory substances, melting readily by the aid of the pure oxyhydrogen, were observed to obstinately refuse liquefaction at all when subjected to the influence of the latter compound; a blowpipe thus fed by a mixture of coal gas and oxygen, even when both at the same pressure, is very weak as regards its action, the most serious drawback being the difficulty of obtaining a flame uniform; first the outer part of the flame being hottest, then the innermost. These difficulties will be found altogether obviated by using the electro-oxyhydrogen blowpipe, as shown in the accompanying diagram, which, after several different constructions as regards pattern, appears thus in one of its simplest and most effective forms: A A, consisting of a glass U-tube of suitable dimensions mounted upon stand and furnished with interior platinum plates; B B, in contact with acidulated water, which is introduced into the apparatus before using the same, the blowpipe in connection with the upper part allowing the gases to mix in the ordinary way. Thus is constructed the most effective blowpipe ever introduced to the scientific world; being perfectly automatic, of almost indefinite duration, and requiring no taps as regulators, the gases being evolved in exact proportion to reform water, while the flame is regulated at will by means of the electric current. By similar construction upon a larger scale an automatic furnace may be arranged.—*Chem. News.*

A NEW FORM OF INFLUENCE MACHINE.*

By JAMES WIMSHURST.

IN April, 1891, I had the honor to submit to this meeting a very useful form of experimental influence machine, by means of which I was able to show that almost every combination of glass and metal, and also that plain glass disks, when moved and suitably touched, were capable of producing a flow of electricity.

It is one of those combinations, somewhat modified and extended, which I have now the further pleasure of bringing to your notice.

The machine consists of two disks of plate glass, each of 3 ft. 5 in. diameter and ¼ in. thickness, mounted about ¾ in. apart on one boss and spindle. This spindle is driven by means of a handle, and the disks rotate in one direction.

* Read June 28, 1893, before the Physical Society.

In the space between the disks are fitted four vertical slips of glass, two being situated on the right hand side of the machine and two on the left hand.

The vertical edges of the slips which come nearest the spindle are cut to an angle, leaving a rather wider opening at the circumference than at the center of the disk. Upon each slip is a brush, A, and also an inductor, the brush and the inductor being metallically connected; the brushes are made of fine wire, and touched very lightly on the inner surfaces of the disks. The glass slips slide into place by means of suitable grooves at their top and bottom ends; they may be removed and replaced readily at pleasure.

The essential parts are fitted together within a glass case, and in all respects the machine is so constructed as to be useful for experimental work. The limited size of the case causes the insulating distances between part and part to be small; hence the length of the sparks is reduced. All the surfaces are coated with shellac, and when the brushes are new and in proper condition, the machine is self-exciting.

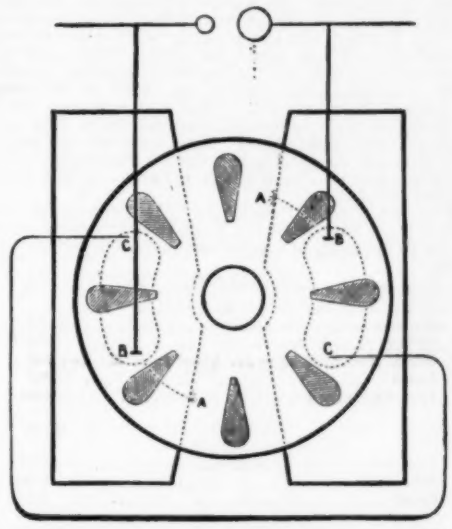
The charges are not subject to reversal when the terminals are opened beyond the striking distance, for then the whole of the induced charges pass by way of the neutralizing brushes, C, C. Another feature is that the neutralizing current may also be broken without reducing the excitement, but then the charges alternate from positive to negative with each half revolution of the disks.

An approximate measure of the efficiency of the machine is seen by the following experiments.

The glass throughout was held free from electrical excitement, and the disks were rotated 60 times per minute; the actuating cause was then removed, and the disks came to rest after making 47 revolutions. This measures the friction of the machine.

The disks were then similarly turned, but the electrical charges were allowed to collect; it was then found that the disks came to rest after 23 revolutions. The friction of the machine, therefore, is about equal to the repulsion of the electrical charges.

Leyden jars, having eight square inches of tinfoil in each coating, were then connected to the terminals,



A, A, brushes connected metallically to the inductors; B, B, collecting brushes connected with terminals; C, C, brushes connected with the neutralizing circuit.

and the terminals set 3½ in. apart; the disks were turned to the same number of revolutions and then left to come to rest, which they did after producing 80 sparks.

The disks were then turned and the number of sparks counted in relation to each revolution. This gave seven sparks of 1 in. length, five of 2 in., four of 3 in. and three of 4½ in. length.

Eight metal sectors were then added (total 112 square in. on each disk); with them the self-excitement becomes so free, that before any circuit was made, presenting the fingers to the disks caused electrical discharges.

When the circuits are made between the several brushes the disks appear to be seething with electricity, and the charges shoot out for a considerable part of their circumference, but chiefly at the top and the bottom, where they are not covered by the vertical glass slips, for the change of the charges from + to — takes place upon the disks just as they pass the edge of the slip. Improvements in this respect might be made, but the present arrangement has the advantage of giving permanence to the respective charges.

It will be noticed that strips of tinfoil are placed over the receding surfaces of the glass slips. They were intended to afford the means for collecting and carrying to earth any part of the charges from the inductors, but the earth connection has not been necessary.

When at work, the charges passing from the disks to the brushes may be heard some considerable distance; they resemble the beating of the floats of a paddle wheel.

The charges are, however, reduced about 25 per cent. by the addition of the sectors.

Further tests have been made by fixing a pulley 3 in. in diameter, to the overhanging end of the spindle, and suspending therefrom by a cord a weight of 15 pounds. The fall of this weight through 3 ft. produced 17 revolutions when the disks were not excited and 10 revolutions when excited. The same Leyden jars were then connected, and it was found that the fall of the weight through 3 ft. produced 28 sparks of 3½ in. length. Reducing this to the terms of work in relation to sparking length, and omitting friction of the machine, it will be seen that 1 pound weight falling through rather less than 12 in. produces a spark of 3½ in. length. It must not, however, be forgotten that a considerable amount of electricity is also passing by way of the neutralizing circuit.

[Continued from SUPPLEMENT, No. 947, page 15137.]

ALLOYS.*

By Prof. W. CHANDLER ROBERTS-AUSTEN, C.B., F.R.S.

Lecture IV.†

THE Japanese have long had the secret of the preparation of a series of alloys in which the precious metals are used in such a manner as to deliberately sacrifice the metallic luster, and, in the case of gold, even its distinctive color, for the sake of producing other definite effects. The brilliancy of gold and silver in their natural state is employed by this artistic nation merely to heighten the general effect of a design, and the result of centuries of patient labor is that the Japanese art metal worker possesses a series of alloys which rival the palette of the painter in range of tint. The nature of the alloys has already been fully described in the lecture to which I have referred, and I will, therefore, merely say that one class of them consist of copper alloys allied to the bronzes, but in which gold and silver replace tin and zinc. The history of their evolution would be most interesting to develop, for the wave of Indian colonization reached Japan in the sixth century of our era, and that would appear to be the earliest period at which such alloys could have been adopted for artistic purposes by the Japanese, "a race which possesses the artistic instinct in certain of its developments in a greater degree than any other in our time. With them the sense of decorative distribution and of subtile loveliness of form and color is absolutely universal, and expresses itself in every most ordinary appliance of daily life, overflowing, indeed, into every toy or trifle that may amuse an idle moment."‡ There are hundreds who will visit the cases of this museum and will bestow appreciative admiration on the Japanese wares, but there are very few who know how the varied effects are produced. Let me, therefore, direct attention to a few selected objects and photographs. Take the simplest case first. Here is a plate (specimen shown) of brown bronze. There is no attempt at producing effect by a raised surface; the artist has simply chosen a plate of bronze, some 8¼ inches in diameter. He has cut a design into the plate and has inlaid that design with a black alloy; wherever he has scooped out the drawing of this beautifully graceful bird he has inlaid the alloy, which now appears bluish black, and he has taken a darker variety of the alloy and has deepened the effect of the wing and tail feathers, and has in that way produced exactly the effect of an Indian ink painting in a dark and comparatively light shade. Now, what are the alloys the Japanese use, and how is the color produced? The following analyses show the composition of the more important of them.

The first is called "shaku-do." It contains, as you will observe from Analyses I. and II.,§ in addition to about 95 per cent. of copper, as much as 4 per cent. of gold.

Shaku-do.

I.	
Copper	94·50
Silver	1·55
Gold	3·73
Lead	0·11
Iron and arsenic	traces
	99·89

II.	
Copper	95·77
Silver	0·08
Gold	4·16
	100·01

Mr. Gowland, an eminent authority on Japanese metal work, tell us that shaku-do has never been used for very large works. It has, however, been erroneously stated that a colossal statue, cast at Nara in the seventh century, is made of it. The quantity of gold is really very variable, and certain specimens I have analyzed contain only 1·5 per cent. of the precious metal. The next important alloy used by the Japanese is called "shibu-ichi," and the following are typical analyses:

Shibu-ichi.

III.	
Copper	67·31
Silver	32·07
Gold	traces
Iron	0·52
	99·90

IV.	
Copper	51·10
Silver	48·93
Gold	0·12
	100·15

There are many varieties of it, but in both these alloys, shaku-do and shibu-ichi, the point of interest is that the precious metals are, as it were, sacrificed in order to produce definite results, gold and silver, when used pure, being employed very sparingly to heighten the general effect. In the case of shaku-do, we shall see presently that the gold appears to enable the metal to receive a beautiful rich purple coat or patina when treated with certain pickling solutions, while shibu-ichi possesses a peculiar silver-gray tint of its own, which, under ordinary atmospheric influences, becomes very beautiful, and to which the Japanese artists are very partial. These are the principal alloys, but there are several varieties of them, as well as combinations of shaku-do and shibu-ichi in various proportions, as, for instance, in the case of kiu-shibu-ichi, the composition of which would correspond to one part of shaku-do rich in gold and two parts of shibu-ichi rich in silver. The precious metals are deliberately sacrificed with a view to obtain a definite effect, a distinct tint that is in the patina, and if gold and silver are employed pure, it is only to heighten the general effect.

With regard to the use of pickling solutions, so far as I have been able to ascertain, they are made up respectively in the following proportions, and are used boiling:

	I.	II.	III
Verdigris*	438 grains	87 grains	220 grains
Sulphate of copper	262 "	437 "	540 "
Niter	...	87 "	...
Common salt	...	146 "	...
Sulphur	...	233 "	...
Water	1 gallon	...	1 gallon.
Vinegar	...	1 gallon	5 fluid drachms.

That most widely employed is No. I. When boiled in No. III. solution, pure copper will turn a brownish red, and shaku-do, which, you will remember, contains a little gold, becomes purple. And now you will be able to appreciate the effect of small quantities of metallic impurity as affecting the color resulting from the action of the pickle. Copper containing a small quantity of antimony gives a shade very different from that resulting from the pickling of pure copper. But the copper produced in Japan is often the result of smelting complex ores, and the methods of purification are not so perfectly understood as in the West. The result is that the so-called "antimony," or shiro-me, of the Japanese art metal workers, which is present in some alloys, is really a complex mixture containing copper, lead, arsenic and antimony, so that a metal worker has an infinite series of materials at command with which to secure any particular shade; and these are used with much judgment, although the scientific reasons for the adoption of any particular sample may be hidden from him. It is strictly accurate to say that each particular shade of color is the result of minute quantities of metallic impurity, and a few examples will, I trust, make it clear that the Japanese arrange true pictures in colored metals and alloys.

The action of these solutions is remarkable. You have copper to which a small amount of silver and a small amount of gold are added. The amount of gold may be variable, and artificers often take credit for putting in much more than analysis proves to be present, but a small amount of gold, it may be only one per cent., is sufficient to entirely change the character of the copper, and when you come to treat it by pickling solutions, you get a totally different result from that which would result from the employment of pure copper.

The series of alloys known as shibu-ichi vary in composition. Sometimes it will contain one half silver and the rest copper, often only one-third silver, the bulk of the alloy being copper; but in all cases the alloys assume, either by handling, by exposure to ordinary atmospheric influences, or by pickling, a beautiful series of light and dark gray tints greatly admired by Japanese, who employ the alloy in almost all pieces of metal work. [The reader should refer to the report to which reference has been made, which gives the composition of a series of plates of metal, brass, shaku-do, shibu-ichi and copper, which were specially prepared to show the texture and tints of various metals and alloys employed by the Japanese. They are modern, and far from being the best examples which could be obtained, but they are, nevertheless, very instructive.]

One of them is a plate 18½ inches in diameter. It is not in the South Kensington collection, but it is so typical that it may as well be taken as an example as any other. A plain surface of copper has first been taken, the design has been drawn upon it, and each leaf or flower has been scooped out and undercut. The leaf or flower would then be made of a particular alloy, say purple shaku-do tipped with gold or red copper, and the whole design is fitted in like a puzzle, and the result is they build up a picture gradually, using colored alloys or alloys which may be colored by the action of a pickle, and they attain the result which is shown. The basis is a plate of copper. Here in one place there is a leaf which is not really raised, but a little sunk below the surface of the original plate. The only relief it possesses is obtained by hammering a light variety of gold over it. Then comes a red bud of su-aka, set with its golden points. Here is a shibu-ichi leaf, half of which is of red su-aka, and if you look closely afterward you will see the bird, or shaku-do, with all its feathers carefully drawn, and the lustrous effect of the plumage produced with really consummate skill by the use of fine lines. Then comes a shibu-ichi flower, with a golden center. This is typical of the work they do; however large or small it may be, they simply inlay these colored alloys, using generally a somber base. The beautiful vase, No. 30, 1886, in the South Kensington collection, has all the typical alloys.

The Japanese do not merely trust to obtaining effects by high relief, as is the case with this plate; very often they employ a darker alloy for producing the effect of painting on metal, so to speak, in a very remarkable way. There is one example in Mr. Huish's collection, a knife handle, which presents the effect of a duck's back and wings in comparatively high relief, with his neck under water. He is a shaku-do purple duck, plunging through silvery-gray water, but his body is in high relief, his neck is of a different *nuance* of tinted shaku-do to the rest of his body, and it is so beautifully let in that it is only in certain lights that you can see it at all, but it produces exactly the effect of the duck's neck being below the surface of the water. I have not that specimen here, but I have in a sword hilt, also from the collection of Mr. Huish, some tiny minnows, each about one-sixteenth of an inch, with minute gold eyes, swimming up a shibu-ichi gray stream, the effect of their being actually below the surface of the water being suggested with marvelous skill. I think at present no European artificer could obtain such a result as that, as it shows the most beautiful effects, not merely of texture, but brilliancy and transparency. The color effect they produce by the use of the pickles—the composition has been already given—but many of the extremely valuable old Chinese bronzes have acquired their tint simply by long exposure to atmospheric influences. If you look, for instance, at No. 100 in the South Kensington bronze cases, it is a Chinese duck of about one foot across, if I recollect rightly, purchased about 1876, and it has a green patina, indicating extreme old age, and although my friend Mr. Gowland says the attribution of it on the label to the third century is inaccurate, still it is an extremely old specimen of bronze, which has acquired its green patina by perfectly natural causes, unaided by artificial treatment, such as the Japanese always employ in more modern work. Again, there is No. 148, a green gourd, in the South Kensington collection, and No. 79, a vase in the form of two cups, base to base, a beautiful mottled red on a green patina, and I think in this case the red is produced by heating and not by pickling. Then if you look at No. 224 in the museum, you will see a bronze fish with scales inlaid with silver, which is very instructive.

The vase, No. 120A, 1878, is given on account of its suggestiveness and the simplicity with which the effect is produced. The upper part is of light bronze and the globular portion consists of a series of bands joined with silver studs or rivets. The uppermost band is of red copper, the next is of liver colored bronze, the next has a brilliant green patina of carbonate of copper, and this is followed by another bright red layer, and then by one of light bronze, the base being either shibu-ichi or silver.

There is one other mode of treatment which I have specially studied, but the South Kensington collection contains only two examples of it, a pair of vases, one of which is a singular combination of banded alloys. The characteristic alloys employed by the Japanese are taken in thin sheets and soldered together. Conical holes are then drilled partly through the mass, so as to penetrate different layers of strata of the mass, and when the whole is beaten flat, of course different layers will come to the surface. Another method consists in raising prominences on the front of the plate by punching the back, and these prominences are then filed flat, producing banded effects of great beauty and complexity. These alloys are often introduced into the tiniest work. A single bead half an inch in diameter may contain hundreds of layers. The names mizu-nagashi (marble) and moku-me (wood grain) are given to the chief varieties. This pair of vases is one of the few examples in this country. It is not particularly good in form, but is of great merit as regards the manipulative skill displayed in its production. The neck, band, and foot are of shaku-do inlaid with gold, while the body of the vase is of mizu-nagashi, consisting of alternate layers of shaku-do and red copper, and there is a silver panel bearing a bird beautifully wrought in gold and colored alloys beaten into the silver. The band round the center is of shaku-do, which has been wrought with fine indentation so as to produce a singularly faithful resemblance to leather.

The South Kensington collection also contains an interesting vase, No. 72, 1889, of old Japanese work in marbled bronze, but the marbling is in the patina alone, for the vase is of solid bronze, and is not made of layers, as in the case just described.

GOLD.

With regard to alloys of gold, I do not think that in modern times we make nearly enough use of the very old alloy *electrum*. It occurs native, and was originally regarded as being a distinct metal, of the same order as gold or silver. Lovely coins were struck from nuggets of it B. C. 700. It was prepared artificially also, as is shown by the following sentence: "As when gold is fused around silver by an experienced man, whom Hephaestus and Pallas Athene have instructed in all kinds of arts, that he may execute graceful works, so did the goddess pour gracefulness around his head and shoulders."* Ultimately, the authors of the middle ages applied the word electrum to yellow bronzes, and more especially to brass. I have one analysis of the true, gold-silver electrum, a specimen in the South Kensington Museum.

No. 28.—A Relic Shrine, or "Stupa," in four parts (incomplete). Gold repousse and chased with conventional ornament in bands. *Burmese.* Discovered in leveling a Buddhist temple at Rangoon in April, 1885. H. 15 in., diam. 12¾ in. 02755.

Analysis.

Gold	72·02
Silver	22·96
Copper	5·24
	100·22

This leads me to speak of the extraordinary effect of metals on gold, effects which we are only now beginning to examine. Take, for instance, the action of aluminum on gold. An alloy containing 90 per cent. of gold and 10 per cent. of aluminum is a brilliant white, but if the amount of aluminum be doubled (really 20 per cent.), then a brilliant purple alloy, ruby colored in its crystals, is obtained; and from the yellow gold and the gray aluminum we have the most brilliantly colored alloy which is as yet known. Greenish gold is produced by adding 14 per cent. of silver to pure gold, and blue gold by the presence of a little iron.

SILVER.

The peculiar grayish tint often seen on the surface of silver wares or on that of silver copper alloys, and known as "oxidation," is readily produced by immersing the articles in a hot solution of sulphide of potassium.

There is, however, a delicate violet tint which may be imparted to silver by converting its surface into a thin layer of chloride, and then allowing the action of light to stain the chloride violet. Messrs. Christofle long ago pointed out that this might be done, and Messrs. Tiffany, of New York, have recently produced some very beautiful articles in this violet tinted silver.

A little specimen of their work has been placed in the museum. It has a damascened ornament produced by protecting certain portions of the chloridized silver from the action of light.

Old work in *niello* hardly comes within the limits of this lecture, but it may be mentioned that M. Lucien Gaillard, of the well known firm of silversmiths of Paris, has recently produced some articles of great beauty in malleable sulphide of silver.

NICKEL.

The specimens of metal work analyzed from the Persian and India collections do not contain more than

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* Lectures delivered before the Society of Arts, London, 1893. From the Journal of the Society.

† Some of the particulars contained in this lecture were given in a lecture delivered at South Kensington Museum in 1892, and some portions, relating to Japanese art metal work, formed the subject of a paper read before the Applied Art Section of this Society, which appeared in the *Journal* June 30, 1893.

‡ Sir. F. Leighton. Presidential address National Association for the Advancement of Art. "Transactions," 1888, p. 22.

§ Analyses Nos. I. and III., both on sword ornaments of the finest quality, are by Mr. Gowland, of the imperial Japanese mint, at Osaka; Nos. II. and IV., by Professor Kallscher, "Ding. Polyt. Journ.," ccxv., 93.

* Sulphate of iron may sometimes replace verdigris.

* Od. vi. 232-5, quoted by Schliemann, 258 Ilios, probably manufactured electrum.

† "Comptes Rendus," vol. 73, 1874. 1019.

small quantities of nickel, some $\frac{5}{10}$ per cent. is all that could be found. This is somewhat remarkable, for there is undoubted evidence of the use of wares in nickel-copper alloys in India. The late Dr. Walter Flight examined several coins of kings of Bactria, of dates varying from 150 to 246 B. C., and found that they contained nearly the same amount of nickel as the modern nickel coinage of European nations—75 per cent. of copper, and 25 per cent. of nickel. One of the specimens analyzed by Flight, a coin of Euthydemus, was found to contain:

Copper	77·585
Nickel	20·038
Cobalt	0·544
Iron	1·048

General Cunningham, in his elaborate paper on the coins of Alexander's successors in the East, inclines to the opinion that the copper-nickel alloy must have come from China. He points out, however, that Quintus Curtius mentions that near the junction of the five Panjab rivers, Alexander received from the Oxydracæ and Malli a present of 100 talents of white iron (*ferri candidi*), which could not have been tin, as that metal was well known to the Greeks, and it may very probably have been a white alloy of nickel and copper.

Analysis No 59 in the report was made on a chopstick case, of modern Japanese workmanship, which was found to contain 6·14 per cent. of nickel.

No. 59.—Chopstick case. *Modern Japanese.*

Analysis.

Copper	65·88
Arsenic	cons. trace
Lead	0·33
Bismuth	trace
Iron	0·37
Nickel	6·14
Cobalt	0·50
Zinc, by diff	26·78
Gold	trace
Silver	trace
	100·00

This sample, from my own collection, was an electroplated one, and was covered with a coating of silver, which was removed prior to analysis. The surface scrapings contained much silver. The color of the above metal was nearly white.

ANTIMONY.

I have already called attention in the analysis No. 40 to the presence of 2 per cent. of antimony in a variety of brass. At the present day we only know antimony as a brittle metal, but Berthelot* analyzed a fragment of a Chaldean vase, which proved to be of pure antimony, so that the ancients must have known some method of making this metal malleable.

Dr. Gladstone† has recently shown that some beads found by Dr. Flinders Petrie in Egypt are of antimony.

Viewing the materials at the command of the art metal worker as a whole, the point I want remembered is this, by the time the elder Pliny, the naturalist, wrote in the first century of our era, and described as well as a cultured gentleman with scientific tastes could the nature of early metallurgy, that industrial art was itself really far advanced, and the art metal worker had excellent materials, mainly bronze, at his disposal. But the artist was far in advance of the metallurgist, if we only judge by the articles of the most common use found in Pompeiian homes, ordinary kitchen utensils which, as Sir Frederick Leighton says, exhibit an amazing wealth of idea and a high level of executive merit, "each bowl, each lamp, each spoon almost, is an individual work of art, a separate and distinct conception, a special birth of the joy of creation in a genuine artist, the chief characteristic of Pompeiian work being the absence of any ugly thing."

If art metal work is to be revived in this country, it will be well to remember that, while in the time of Pliny the art metal worker produced beautiful things with few metals and alloys, his successor of to-day makes but scanty use of the wealth of materials at his command. In this direction France has little to teach us. Take, for instance, the bust representing *Gallia* in the Luxembourg. It was modeled by M. A. Moreau-Vauthier, and executed by M. L. Falize. The face is of ivory; over a chain armor in black silver there is a breast plate in two shades of gold, enriched with topaz and emerald. The helmet of gold is relieved by black niello, and there are two straps of brown bronze, which well represent leather, hung from the helmet. The work is excellent, but how greatly the effect might have been heightened, and the interest in the work deepened, if the artist had only employed the Japanese series of alloys. One artist alone, Alfred Gilbert, has employed them, and, of course, with great skill and effect; and as in him the nation possesses a sculptor whose work is equal to the best days of the Italian Renaissance, we must look to his school for advance in this direction. We may then remove the reproach that we are still far behind the Oriental metal worker. It would appear that neither the purple shaku-do, nor the gray shibu-ichi, is suitable for striking into medals that require even moderate relief; at least, I failed to produce satisfactory medals in either of these alloys, for even the small proportion of gold which, in shaku-do, is added to copper, very materially hardens the copper. Both alloys may, however, be used either in sheets or cast into moulds. The Japanese do use them cast, and it may be well, therefore, to conclude this lecture by a brief account, but little more than an outline, of the method of casting known as *cera perduta*, which suggests an infinite variety of applications for these interesting alloys.‡ It must be imagined that the bust has been modeled in wax (*b*) on a core of plaster (*a*). The drawing is a little too picturesque, for it is the outer layer of wax which determines the actual form assumed by the cast metal. The wax model would have rods of wax (*e*), (*e'*) affixed to it, and at least two rods placed in the position shown at (*f*), (*f'*). A funnel-shaped rod of wax would be placed above the head, so as to leave the opening or "get" (*c*) through which the metal would be poured. The bust with the rods of wax would then be covered with a mass of plaster (*d*) shown by the cross-hatched lines, and when the mass is firmly set and dry the wax would be melted away by surrounding the entire mould with a fire. The wax will then pour out from the lower orifices (*f*), (*f'*), leaving an empty space wherever it had been. There must be suitable supports to prevent the shifting of the core. The ducts (*f*) and (*f'*) are then closed by plugs, and bronze or other metal is then

poured in through the "get" (*c*), filling the spaces left by the wax. The openings (*e*) and (*e'*) serve to allow the air to escape, but they become filled with molten metal, and the rods thus produced have to be cut away from the finished bust. It will be evident that the cautious removal of the plaster of the mould, shown by the cross-hatched lines, will leave a metallic bust in the form of a thin shell investing the core (*a*).

The adoption of this process should afford abundant scope for the extended use of Japanese alloys, for which I have so long and so persistently pleaded.

*"Ann. de Chem. et de Phys.," xii., 1887, p. 135.

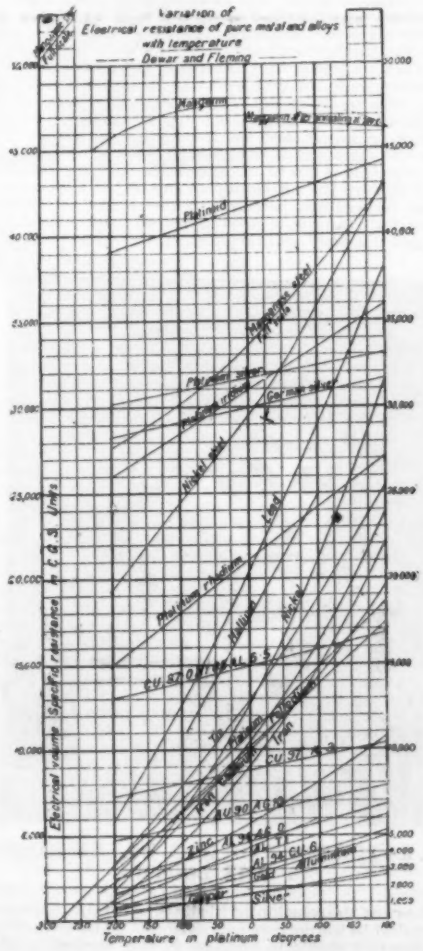
†"Proceedings of the Society of Biblical Archæology," March, 1892.

‡A sufficient account of this method applied to the casting of medals is given in the Mint Report, 1885, p. 25.

LIQUID AIR.

PROF. DEWAR lectured recently at the Royal Institution upon "Some Scientific Uses of Liquid Air."

Prof. Dewar said that the chief scientific use of liquid air consists in the facilities it gives for studying the properties of matter under the excessively low temperature yielded by its employment. When Faraday was working in that Institution in 1823, with such powers as were then under his command, he may be said to have been limited to the study of the specific gravities alone of bodies at a low temperature. By



means of solid carbonic acid he obtained the greatest cold then possible for the liquefying of gases, but at the present time we are in a better position.

He added that during the recent summer Prof. Liveing and himself had continued their work on the optical properties of certain bodies at low temperatures, and Prof. Fleming and himself had done the same in relation to the electric conductivities of metals under the influence of extreme cold. The result of the first series of researches had been to confirm the law of Gladstone, by the results set forth in the following table:

Refractive Indices of Liquid Gases.

	Index.	Ref. constant.	Ref. molecular.
Oxygen	1·2236	1·989	6·364
Ethylene	1·3632	0·626	17·528
Nitrous oxide	1·3305	0·268	11·587
Nitrogen	1·2053	0·223	6·300
Air	1·2062	—	—

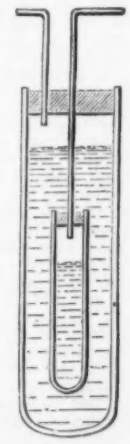
Law of Gladstone, $\frac{\mu - 1}{D}$ = constant.

The diagram shows the result of the latest experiments of Prof. Dewar and Prof. Fleming on the electric conductivity of metals at very low temperatures. They all point to the conclusion that at the zero of temperature all metals would become perfect conductors.

When speaking of the great impermeability of a high vacuum to heat, he drew attention to a simple method of demonstrating it designed by Crookes. Two thermometers were fixed side by side, the bulbs of each covered with similar glass jackets, in one jacket of which was a high vacuum, and in the other common air. He then placed the bulbs of the thermometers in hot water, and the liquid employed rose much more rapidly in the air-jacketed tube than it did in the other.

In his own experiments it had been found convenient to use mercury vacua, and the question had arisen, "How long does it take for the vessel to become filled with vapor of mercury?" this being important in relation to the action of mercurial pumps. It takes a very short time indeed to saturate an ordinary bulb with vapor of mercury from the liquid metal, and mirror after mirror may be brought down upon the interior of the bulb by the local application of liquid air outside. Frozen mercury will scarcely give traces of a mirror. If two vacuum bulbs connected by a short tube one-eighth of an inch in diameter be used, with mercury in one of them, and if the vapor be then thrown down in the other by freezing, it takes a long time afterward for the mercurial atmosphere remaining to get into a state of equilibrium; in fact, the power of depositing mercury in the bulb free from the liquid is almost stopped at first, unless a drop of the mercury is allowed to enter it, upon which a mirror can then be instantly produced by sufficient cold. In a closed vessel containing air, a frozen mercury mirror rapidly disappears when the cold is withdrawn. When extreme cold is applied to a bulb containing nothing but vapor of iodine, the iodine comes down where the cold is applied, as a violet deposit. A faint electrical discharge will go through such a bulb, but not through one first filled with vapor of mercury, and then chilled; the spark then seems inclined to go anywhere but through the bulb. These points were all illustrated by experiments.

In solidifying common air, Prof. Dewar took two large vacuum-jacketed glass test tubes, as in the accompanying cut, the smaller one placed inside the



larger, and both containing liquid air. Each vessel had its separate tube communicating with machine air pumps in the laboratory, where the pumps are driven by a gas engine. After a time, what with cold produced by the rapid evaporation of the liquid air in the outer tube and what with the cold produced in the liquid air in the inner tube by its own evaporation, and what with the protection from outside warmth by the two vacuum jackets, a button of solid air looking like ice is at last obtained at the bottom of the inner tube. It quickly goes back into liquid air when the pumping ceases. This experiment was tried three times before it succeeded, and it answered only with freshly liquefied air. Too much of the nitrogen had boiled off from air liquefied before the lecture and preserved to some extent in jacketed glass flasks covered with carbonic acid snow. Oxygen has not yet been frozen, except when mixed with a large quantity of nitrogen. As the liquid air grew denser before freezing striæ were seen in it. The lecturer explained a method of performing experiments relating to heat with liquid air. In the first place, he showed that for several minutes at a time, while in vacuum-jacketed vessels, it is practically a stable liquid, from the few bubbles of it in gaseous state given off in the time and rendered visible by collection in an inverted glass tube with its open end in the pneumatic trough. Then, by dropping into the liquid air a piece of platinum or a little mercury charged with a known amount of heat, followed by others, known increments of heat may be communicated to the liquid.

The effect of great cold upon the cohesion of metals he had only been able to examine tentatively, but in every case tried the tensile strength had been increased. Iron at −180° C. has twice its normal tensile stress resisting power as shown in the following table, for which he would scarcely hold himself responsible, because his testing apparatus is not yet perfected. The jaws of

the machine had to be immersed in liquid air, of which they had used gallons during the experiments.

Breaking Stress of Metals.

	15° C. Tons per sq. in.	−180° C. Tons per sq. in.	15° C. Elongation per cent.	−180° C. Elongation per cent.
Copper	22·3	30·0	6·8	13·4
Iron	34·0	62·7	8·2	4·7
Brass	25·1	31·4	35·5	32·2
G Silver	38·3	47·0	10·7	20·4
Steel	35·4	60·0	29·4	19·5

The lecturer produced a card painted red with mercuric iodide, and wherever he drew a pad of cotton wool across it dipped in liquid air, the cold made the red color turn to yellow, or in other words caused mercuric iodide to exercise a changed influence upon the incident and reflected light; as the cold passed away, the substance returned to its normal color. The cold slightly alters certain organic coloring matters, but not to the same extent, so far as he had tried.

A soap bubble dropped into a tube, at the bottom of which liquid air is evaporating, becomes frozen, and keeps its colors, except that he has never yet succeeded in freezing the black spot of the soap bubble.

An American experimenter had found that the temperature of −80° C. reduced the power of the magnet, but this takes place alone with supersaturated magnets; with a normal charge of magnetism the power is increased. He coiled a wire round a magnet, and then, when he dipped its poles in liquid air, an electric current was generated in the wire. At −180° C. the power of the magnet is increased 50 per cent. Faraday thought it probable that at low temperatures metals might be much more magnetic.

He performed several experiments with ordinary high vacuum tubes, showing that in all cases the chilling of them outside with liquid air prevents, or nearly prevents, the passage of the discharge inside the tubes.

Professor Dewar gave the following figures in relation to some of his experiments on thermal transparency.

Amount of Heat Transmitted through a Cylindrical Glass Vacuum Vessel containing the following Liquids.

Colza Lamp Radiation.

Chloroform	1·0
Carbon bisulphide	1·6
Liquid oxygen	0·9
Liquid nitrous oxide	0·93
Liquid ethylene	0·60
Ether	0·50

By favor of Professor Dewar we are in receipt of an advance proof of one of his past lectures on "Liquid Atmospheric Air," and gather therefrom the following particulars not previously published in these pages.

He says that mercury vapor, even below a millionth of an atmosphere pressure, behaves like an ordinary saturated vapor, and that the mercury therein can be brought down as metal by cooling a part of the outside of the bulb to −180° C. by the application of a pad of cotton wool saturated with liquid oxygen; if this mirror, however, be kept cold, another mirror cannot be brought down upon another part of the bulb by the application of the same low temperature. His experiments led him to conclude that in the high vacuum thus produced glass itself gives off some kind of vapor. The perfection of the vacuum in different vessels thus prepared, all treated in the same way, differs very much, and after use they almost invariably deteriorate. This leads us to suggest that experiments with different kinds of good glass are desirable, especially with the sixty or more now made for optical purposes and upon scientific principles at Jena.

As yet he has found none among the many substances examined which will aid in giving such good vacua as does mercury. Sulphur has been tried and not found to be an improvement, chiefly because traces of organic matter are decomposed by the sulphur, giving sulphureted hydrogen and sulphurous acid, which dissolve in the sulphur and remain therein.

Professor Dewar says that an interesting experiment may be made by immersing an electric pile, composed of carbon and sodium, into liquid oxygen, when almost immediately the electric current ceases. The gaseous oxygen coming from the liquid must be exceedingly pure and dry, and as it has been alleged two chemical substances require the presence of a third one in order that they may combine, it was interesting to ascertain if a substance like sulphur would continue to burn after ignition in such an atmosphere. Sulphur placed in a small platinum vessel that had just been heated to redness was raised to the boiling point, and in the act of combustion lowered into a vacuum vessel containing liquid oxygen. The combustion continued active, and for a time could be maintained in the middle of the liquid oxygen. This result suggests that oxygen and sulphur can enter into combination in a perfectly dry condition.

He says that the best test of the quality of any vacuum obtained is in the relative rates of evaporation of liquid oxygen under the same conditions in different vessels. In many of the large vessels used for the storage of liquid gases, it is convenient and more effective to cause the deposition of a mercury mirror over the surface of the inner vessel, by leaving a little liquid mercury in the lower part of the double-shaped flask, instead of silvering, as previously described. Under such conditions the mercury instantly distills and forms a brilliant mirror all over the surface of the inner vessel. The facts that mercury has a very high refractive index and is a bad conductor of heat are factors of importance in retarding the conveyance of heat. After the mercury mirror has been formed, any further increase in the thickness of the film can be prevented, and at the same time the vacuum improved by freezing the excess of liquid mercury in the lower part of the vessel. The vacuum vessels described equally retard the loss as well as the gain of heat, and are admirably adapted for all kinds of calorimetric observations. The future use of these vessels in thermal observations will add greatly to the accuracy and ease of conducting investigations.

ART AND OPTICS.*

THE guardian who, in the intervals between divine services, guides visitors through the pretty Russian church of Geneva, directs their attention to a painting representing, of natural size, a youth bearing a palm and advancing toward them. There is no question of it, the motion of his feet indicates that he is moving at right angles with the canvas; but, if one moves to the right or to the left, the feet seem to turn, and as obliquely as one may look at the painting, the young man is always advancing toward him. The astonishment at this singular spectacle is carefully kept alive by the guardian, who goes into raptures before this extraordinary display of skill of an artist who has discovered a secret of perspective; and, as the place leads him more to contemplation than to analysis, the spectator remains surprised to see the handsome young man ever directing himself toward him. But, later on, reflection asserts its claims, and one would then be tempted to propose to the painter a much more extraordinary problem still, and that is so to manage that a person shall advance toward the spectator standing before him, and not follow him when he moves to one side.

The case that we speak of is rare, or else little attention is paid to it, but every one knows that a portrait follows everywhere with its eyes the person that is looking at it, and to such a point that a slightly uncomfortable feeling sometimes results from it. We shall revert to this after recalling a few simple facts.

In the first place, do we not, by a skillfully drawn perspective, become deceived as to the relative size of objects? A well known optical illusion is that of a

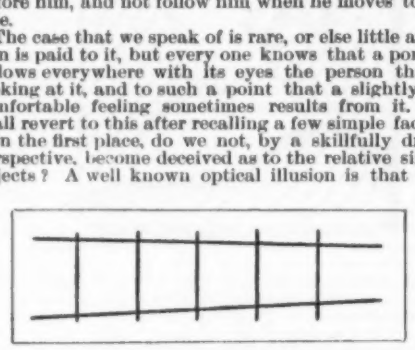


FIG. 1.—THE VERTICAL LINES ARE ALL EQUAL.

long passageway in which several persons are placed. If they are exactly of the same size, they will seem to increase in measure as they stand in more distant planes. The few lines marking the corners of the passageway give us so well the impression of a vanishing, and we so well feel that these converging lines in reality represent parallel ones, that the small images, all equal, are unconsciously measured by a variable unity. There is here not only the elementary illusion due to the approaching of the lines (Fig. 1), but a more complex illusion due to the unconscious interpretation given to the drawing of perspective.

In Fig. 2 we have endeavored to give a contrary illusion. A bridge is decorated with flags, which perspective ought to make appear equal, as well as the arches of the structure, and we judge them such by the interpretation of the drawing, but the feeling of reality to which the latter corresponds has such an influence upon our judgment that we shall never estimate the furthermost arch such as it is seen in the small one figured in the interior of the first. We have therefore made the first point that in a drawing we judge very badly of the relative size of objects. Their surrounding, distant or near by, makes them appear smaller or larger, and in a proportion greater than might be supposed at first sight. But, as we shall see, this principle is not of an indefinite elasticity.

Is a picture the projection of the object that it represents? Sometimes, perhaps, but certainly very rarely. When, for example, a person presents himself under an odd and not very ordinary aspect, the knowledge that

FIG. 3.—PORTRAIT OF MAN IN THE MUSEUM OF THE LOUVRE.

we have of the relation of his lines re-establishes him in our mind in his correct proportions. If he is very near by, our eye, seeing in succession the various parts of his body, applies a different scale to the visual angle, so that everything is brought back to its true size. Such is not always the case in an image, and we shall not dwell upon the unfortunate photographs by inexperienced amateurs in which the feet and hands take up so large a space. In a picture the person is often seen close by, but the artist has not only projected him; he has interpreted him. What would be thought

* See article on this same subject entitled "The Descriptive Arts and the Exact Sciences," in SUPPLEMENT No. 909.

of the Venus of Milo by those who might judge of it through a photograph only? In the hall in which it is placed at the Museum of the Louvre, the photographer is too near and especially is he placed too low. The spectator re-establishes the direction of the lines in his mind, but in the camera they are marked as one has never seen them, or at least as one has never felt them, and it is thus that the photograph gives us a long-necked Venus of a not very pleasing aspect. But, it may be said, it will suffice to look at the image in the direction in which it has been taken, and the true dimensions will be re-established of themselves. That, even, is not exact, for only by the aid of an artifice can we bring the image back upon a plane at right angles with the visual ray. In reality, we perceive it upon an oblique plane, and instead of judging of the image by

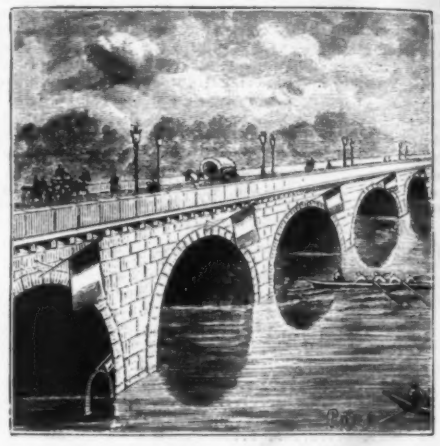


FIG. 2.—PERSPECTIVE OF A BRIDGE WITH THE FARTHERMOST ARCH SHOWN BY DOTTED LINES WITHIN THE FIRST.

the angle at which its various parts are seen, we measure it by the real length of the lines upon the paper, and it always appears distorted. There is an automatic process of giving the aspect of the solid state, but we shall be content to say for the moment that a draughtsman, stationing himself at the same place as the photographer, will give us an image of the goddess that will in nowise shock us, because he will have corrected what the simple projection possesses of faultiness. Let us take another example, geometrically simpler. A picture of large dimensions generally corresponds to quite a large total visual angle, often greater than 30 degrees. Let us consider a sphere placed at the edge of the picture not far from its horizontal median line. Its projection is an ellipse, whose elongation is clearly shown in the conditions that we have supposed, and it will appear such in a photograph; but what painter is there who, in order to remain within the bounds of geometrical accuracy, will represent a sphere by an ellipse? It is not thus that he sees it, for in shifting his glance he carries along the plane of projection, which remains always at right angles with the visual ray; and the spectator, for the reasons given above, finds a circle of more advantage than an ellipse for the representation of a sphere.

We can now return to our starting point, and explain it in beginning with a simple geometrical figure. Let us take Fig. 2 again. On placing ourselves properly in face of the engraving, we see exactly the direction of

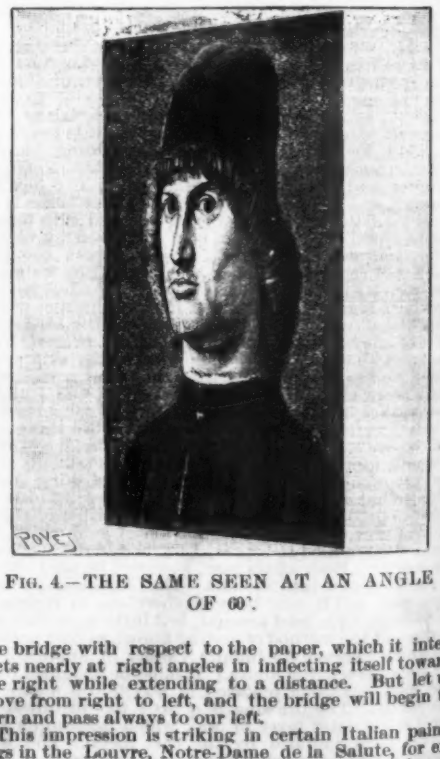


FIG. 4.—THE SAME SEEN AT AN ANGLE OF 60°.

the bridge with respect to the paper, which it intersects nearly at right angles in inflecting itself toward the right while extending to a distance. But let us move from right to left, and the bridge will begin to turn and pass always to our left.

This impression is striking in certain Italian paintings in the Louvre, Notre-Dame de la Salute, for example. If, when we are situated very obliquely, we bring the paper at right angles with our visual axis, the landscape no longer experiences anything but an insignificant displacement, although at this moment we are communicating to it all the rotation that we have just attributed to it. It is here the proportion

occupied by the various portions of the picture on the paper that gives us the idea of the form and direction of the objects, and such proportion remains nearly the same in all our displacements. Moreover, as in every position we have a perception of the direction of the paper, we re-establish in our mind the intention of the draughtsman, and the objects appear to us seriously distorted only under the almost rasant incidence. If we now pass to a portrait, we shall immediately find that the direction of the gaze is manifested to us by the proportion of white that is found above and below the iris and to the right and left of it; and as the eye is strongly convex, such proportion varies rapidly with the position of the spectator. Upon a canvas, such proportion remains constant, and it is for this reason that the gaze seems to follow us. But if, through some not very artistic artifice, we give the canvas a suitable curve at the point of location of the eyes, the latter will appear to be absolutely fixed, and, as the perspective of the face contributes to the effect of rotation, the portrait will seem to turn toward us, while the gaze will preserve a constant direction. Antonello of Messina's admirable portrait of a man (Fig. 3) shows us in a striking manner the oblique gaze that follows us in all our movements, passing always to our right, even when we place ourselves almost in its plane. At 60 degrees from right angles, it scarcely appears distorted, while in reality we see the image represented in Fig. 4—a sort of caricature whence all relief has disappeared.

It is thus that appear to us the portraits hanging on the walls in photographs of interiors. A comparison of Figs. 3 and 4 shows us how great is our tolerance for images seen in an oblique direction.

How difficult it is to represent the eyes by sculpture is well known. A singular fact, ascertained by Mr. Waldeyer, a German scientist, is that in the Greek statues the curve of the eyes is sensibly less than that of our visual organ. Why such singularity with a people who have so faithfully copied nature? It seems evident that the artist rendered the impression without servilely copying the reality. Now, the true visible surface of the eye is that which, starting from the sclerotic, continues through the iris, in which the pupil appears like a projecting point. It is doubtless this surface that the Greeks followed. The color did the rest.

The Egyptians, it is said, incrusted the eyes in quartz. Certain Hindoo idols have eyes of black diamonds, yet in this case we must perhaps see the idea of honoring the essential organ of the god, rather than an artistic intention. We desired to explain the walk of the young man of whom we spoke at the beginning of this article, but we can now dispense with doing so, since all the reasons for it have been given in what precedes. We desire only to insist upon the fact, of which we shall find numerous examples, that the artist in falsifying the principles of optics arrives at the truth much better than he who conforms to them.—*C. E. Guillaume, in La Nature.*

AN improved system of increasing the illuminating power of common house gas by burning the fumes of heated oils in conjunction with it, by C. H. Harrison, London, consists of a metal oil holder, into which ordinary coal gas enters through a tube, and leaves it through other tubes, passing to the burners. It is so placed that the burner heats the oil and drives off from it vapor, which mixes with the gas before burning. The apparatus is fixed to the pipe or gas fitting.

THE FIELD COLUMBIAN MUSEUM, CHICAGO.

THE fine arts have made way for natural history in the beautiful building at Jackson Park, and it is hoped that by May 1 the doors of the young but thriving museum will be thrown open to the public.

The total floor area available for display purposes aggregates 234,828 square feet. In addition to this there are several hundred thousand square feet of wall space that will be occupieed by cases. These areas are subdivided among the various departments, in each of which installations are being made under the supervision of a competent chief.

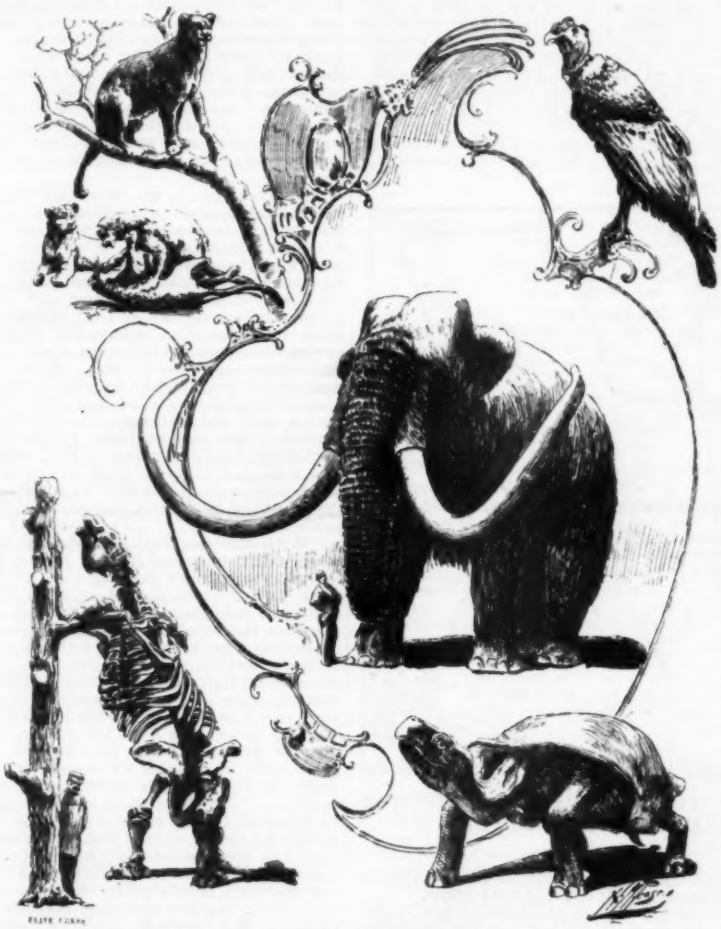
Prof. Ward and a staff of experts have arranged the Ward zoological collection purchased by the museum. It is installed in the southwest section of the building and overflows into the west court. Several of the most interesting specimens of this remarkable collection are shown in our illustrations, for which we are indebted to *Elite*.

In the center is the "Mammoth," reconstructed after bones found near Stuttgardt, Wurtemburg. Left upper corner, "Group of Pumas," from Colorado. Right upper corner, "Peruvian Condor," very rare. Left lower corner, "Megatherium Cuvieri," modeled from remains found near Buenos Ayres. Right lower corner, "Colossochelys Atlas," from India.

The museum will probably lose Mr. L. Z. Leiter's contribution of $100,000. The terms of the gift required that the aggregate collection should be known as the Columbian Museum, with permanent location at Jackson Park. The museum has already been named in honor of Mr. Field, and no stipulation has been made as to its final domicile.

The museum trustees are considering the advisability of purchasing the C. B. Corey ornithological collection of Boston. Mr. Corey's fame as an ornithologist is world wide, and his collection the rarest that could be obtained. It is valued at $100,000, and is offered for $17,000, a sum that will little more than pay the expenses of preparing the collection for shipment to Chicago.

The report submitted by the insurance underwriters, a few days ago, on the fire-resisting qualities of the Fine Arts building is not particularly flattering; but it is asserted by Mr. Burnham that the structure can be made practically fireproof by putting iron beams under the main floor and laying hollow tile between the floor and the beams. The cost of this improvement is estimated at $100.000. The exterior of the building can be made permanent by terra cotta or cast Portland cement, reproducing all the ornamental details, at an estimated expense of $250.000.



MAMMOTH AND OTHER OBJECTS IN THE FIELD COLUMBIAN MUSEUM, CHICAGO.

INTELLIGENCE OF THE CHIMPANZEE.

"THE Royal Natural History." Edited by Richard Lydekker, B.A., F.G.S., etc. (London: F. Warne & Co.) If the two parts of this book which have been already published are fair samples of the thirty-six in which it is to be completed, the complete work will certainly be the handsomest and most readable book on general zoology which has yet appeared. It does high credit to all who have had a hand in its production, being not only full of information conveyed in simple and more comprehensible language than zoologists ordinarily employ, but it is beautifully illustrated with woodcuts and colored pictures that exhibit a high degree of artistic merit controlled by scientific accuracy. In the two parts before us we have the first installment of Mr. Lydekker's treatise on mammals, which is to extend over fifteen monthly issues, and is to be followed by an important section devoted to birds, to which Dr. Bowdler Sharpe, Mr. Ogilvie Grant and Mr. Macpherson are to contribute largely; the remaining twelve parts will continue the survey of the descending series of forms of life to the lowest of the invertebrates. Part I. has a capital introductory chapter on mammalian characteristics, and the attack on the constituent orders is opened with an exhaustive survey of the primates, which are reviewed *seriatim* from the anthropoid apes to the colobine monkeys; the subsequent groups down to the marmosets occupying the second part. Every genus is described in full, over a hundred and thirty representative species coming under notice, most of them at considerable length, with much that is interesting as to their distribution, habits and history; and this information is not of the obsolete, hearsay kind frequently thought good enough for repetition in popular works on zoology, which contain much that the student has subsequently to unlearn. The chief place among the many excellent features of this work must be given to the broad and powerful treatment of the paleontological side of the subject, which, as our readers already know, Mr. Lydekker is specially fitted to deal with. Every species is compared with its nearest allies or direct representatives as revealed in the record of the rocks. The illustrations are very numerous and cannot be too warmly praised.

Mr. Lydekker's description of the larger anthropoid apes will be found extremely interesting. He reminds us that a full grown male gorilla, if standing in a perfectly upright position, will generally measure rather more than six feet in height; and since his body is much more bulky, and his limbs are longer than those of man, he is considerably the largest representative of the primates. Gorillas habitually live in small families, having young ones of various ages with them. They live a wandering life and do not frequent the same sleeping place for more than three or four consecutive nights, traveling considerable distances through the dense forests in search of fresh supplies of suitable food.

Although in appearance male gorillas are somewhat unwieldy creatures, yet they are most active and indefatigable climbers, and are said to ascend to the very tops of the forest trees, where they pass from tree to tree almost as readily as the far lighter spider monkeys of Brazil. They are also capable of taking leaps from great heights to the ground without damage to themselves. Herr von Koppenfels says that he saw an adult spring from a tree at a height of some thirty or forty feet, and on alighting disappear into the scrub.

Of all the large man-like apes, those which on the whole make the nearest approach in bodily structure to man are the chimpanzees of western and central equatorial Africa. In the autumn of 1883 a young chimpanzee, called "Sally," was purchased by the Zoological Society of London. Mr. Bartlett, the superintendent of the society's gardens, soon recognized that she was very different from the true or common chimpanzee, and he considered that the animal was probably one of the black-faced chimpanzees, termed by Du Chaillu "bald chimpanzees." The ordinary chimpanzee has a white or pale flesh-colored face, hands and feet, and is a vegetable feeder, but "Sally" showed a disposition to live upon animal food. Mr. Bartlett says that soon after her arrival he found that she would kill and eat small birds; seizing them by the neck, she would bite off the head and eat the bird—skin, feathers and all. For some months she killed and ate a small pigeon every night, but after a time her keepers supplied her with cooked mutton and beef tea, upon which she did very well. She was an expert rat catcher, and caught and killed many rats that entered her cage during the night.

Mr. Bartlett soon recognized that her intelligence was far above that of the ordinary chimpanzee; she quickly recognized those who had once made her acquaintance, and paid marked attention to men of color by uttering a loud cry—*bun, bun, bun.* Dr. J. G. Romanes made her acquaintance and endeavored to test her mental powers. His account of her was written in 1889, after she had been nearly six years in the Zoological Gardens. He compared the intelligence of "Sally" to that of a child a few months before emerging from the period of infancy, and considered that it was far higher than that of any other mammal, with the exception of man.

In spite, however, of this relatively high degree of intelligence, the creature's power of making vocal replies to her keepers, or those with whom she was brought into contact, were of the most limited kind. Such replies were restricted to three peculiar grunting noises. One of these indicated assent or affirmation; another, of very similar intonation, denoted refusal or distrust; while the third, of totally different intonation, was used to express thanks or recognition of favors. In disposition, says Dr. Romanes, "Sally" was, like many of her sex, apt to be capricious and uncertain, although on the whole she was good humored and fond of her keepers, with whom she was never tired of a kind of bantering play, which was kept up at intervals almost continually. By singing in a peculiar kind of monotone in imitation of her own utterances, her keepers were usually able to induce her to go through a series of remarkable actions, the meanings of which were not very apparent. First she would shoot out her lips into a tubular form, uttering at the same time a weird kind of howling note, interrupted at regular intervals. The pauses would, however, gradually become shorter and shorter, while the sing-song became louder and louder, until it finally culminated in a series of yells and screams, not unfrequently accompanied with a stamping of the feet and a violent shaking of the netting of her cage. After this climax the utterance of a few grunts terminated the performance.

It occurred to Dr. Romanes (from whose account Mr. Lydekker quotes) that "Sally" would be a good subject on which to test the powers of an ape's intelligence. He found, however, that his experiments were seriously hampered by the effects on the creature of the visits of the numbers of people who were constantly passing in and out of the room in which she was kept, and there is consequently little doubt that under more favorable circumstances the results ob-

tained would have been more remarkable than they are. Having secured the assistance of the keepers, Dr. Romanes requested them to ask "Sally" repeatedly for one, two, or three straws, which she was to pick up and hold out from among the litter strewing her cage. The number of straws asked for was constantly varied and never followed any regular order, and when the correct number was presented the animal was rewarded by a piece of fruit, while if the number was incorrect her offer was refused. In this way the ape was easily taught to associate these three numbers with their names. Lastly, if two or three straws were demanded she was taught to hold one or two in her mouth until she had picked up the remaining straw, and then to hand the two or three straws together. This prevented any error arising from her interpretation of vocal tones. As soon as she understood what was required, and had learned to associate these three numbers with their names, she never failed to give the number of straws asked for. Her education was then extended in a similar manner from three to four, and from four to five straws. Here Dr. Romanes allowed her education to terminate. But one of her keepers endeavored to advance her instruction as far as ten. Although she very rarely made a mistake in handing out one, two, three, four or five straws, and was usually accurate in handing out as many as six or seven, when the numbers eight, nine or ten were named the result became more and more uncertain, so as to be suggestive of guesswork.

It was evident, however, that she understood the words seven, eight, nine and ten to betoken numbers higher than those below them; and if she was asked for any of these numbers, she gave some number that was above six and not more than ten. On the whole, therefore, while there was no doubt that "Sally" could accurately count up to five, beyond five her accuracy of computation became progressively diminished. Owing to the method of picking out the straws above described, the operation was a slow one and imposed a considerable tax upon her patience; and as her movements were deliberate and her store of patience small, Dr. Romanes thought that the uncertainty which attended her dealing with the numbers six and seven was more frequently due to her losing patience than to her losing count, although after seven he believed that her computation of the numbers became vague.

We heartily concur with the popular Secretary of the Zoological Society in commending "The Royal Natural History," not only to every naturalist, but to every lover of nature.—*Knowledge.*

THE TYRRELL EXPLORATION OF THE TERRITORY WEST OF HUDSON'S BAY.

THE *Express* has at various times had occasion to chronicle the discoveries of explorers in the Canadian Northland, and this week is enabled to give an account of the Messrs. Tyrrell, who of all the exploratory staff, are most the talk of the Dominion at the present. Hitherto the work of discovery has been paid for out of funds provided for that purpose by the British government, and it was left to the Tyrrell brothers to inaugurate the purely Canadian expedition and to bring it to a most satisfactory close. The chief of the party was Mr. Joseph B. Tyrrell, geologist, and a Toronto University graduate. His brother, Mr. James W. Tyrrell, surveyor, acted as geographer.

Although still a young man, Joseph Tyrrell has seen eleven years of this sort of service, having covered the country from Lake Winnipeg to the Columbia River, across the Rockies, and from the boundary line as far north as the top of Hudson's Bay; while his brother is known to be no novice, from his having acted as surveyor for Lieutenant Gordon on his recent Hudson's Bay expedition.

When geologist Tyrrell landed in Toronto the other day he was attired in Arctic summer weather habiliments of gaudy scarfs, leggins, moccasins and blanket ulster that made the populace shiver as he navigated toward the up-town residence of his brother, Dr. Tyrrell. He looked the picture of health, and was brown as a nut. All the way up to Dover Court road at intervals he found himself breaking into an Indian lope, such was the force of the snow-shoe habit. His story as related to the *Express* representative will be found of uncommon interest.

"In 1892, when I was exploring on Lake Athabasca, I sought to obtain from the Indians some idea of the country to the northward, and they told me of two or three routes that they took to their hunting grounds, skirting the Barren Lands. They knew on the other side of the divide rivers had sources, but had no idea where they flowed to. The Barren Lands had long been a district of mystery to the government, known only to Indians themselves in a sort of legendary way, and the department at Ottawa to whom I reported resolved to explore the country between the Athabasca and Mackenzie River basins and Hudson's Bay, and to determine whether or not the vast area of 200,000 acres could claim richness in fur-bearing animals or minerals I was put in charge, and when on May 26 we assembled at Edmonton, our party consisted of myself and brother, three Prince Albert Indians and three Caughnawaga Iroquois. I did not trust to the Athabasca Indians for help, because I had found in the preceding summer a general belief that any one entering the Barren Lands was sure of being devoured by Esquimaux. The Indians from Montreal were taken because of their adroitness in canoe work, and I don't think a better steersman exists in the world to-day than Peter French, who handled my canoe. It was he who got himself into the papers a few years ago for running the Lachine Rapids on Christmas Day, out of sheer bravado.

"From Edmonton in wagons we drove our two Peterboro canoes, each with carrying capacity of 1,800 pounds, to Athabasca Landing. At Fort Chippewayan or Chipwyn we gathered supplies, in weight about 2,000 pounds, and possessing ourselves of a third canoe used in a former expedition, we set forth eastward, making as we went a survey of the north shore of Lake Athabasca. The last place that Indians were encountered was at Fort Fond du Lac, half way along the shore.

"This was formerly an important Hudson's Bay post, built to gather reindeer meat for their Mackenzie River forts, but now abandoned save for the presence of a few Indians in the vicinity. In a box consigned to Fort Chipwyn left in June with some of the latter was a letter, that the Ontario papers published in October, making mention of a native guide secured to take us up to the Barren Grounds. That guide deserted the very day after I wrote that letter.

"You see, bordering on the Barren Lands, is a wooded belt of about 100 miles; this is the farthest the natives ever penetrate, and the Indian thought by leaving us in the lurch we would be deferred from our purpose. He did not want us to know the way into their hunting grounds, and said, although perhaps we didn't want to hunt ourselves, we would show other white men the way, and take the food out of the natives' mouths.

"I meet this difficulty every year," said Mr. Tyrrell, "but can't blame the poor Indians at all. In a way, what he said is perfectly true. Well, from the end of Lake Athabasca, without guide or maps, we struck northeasterly on one of the routes I had heard of in 1892, ascending Black River into Black Lake and arriving at the southerly edge of the Indian hunting ground by the beginning of July. Still in the same direction our course lay up a small river, where portages were frequently resorted to to overcome rapids and falls, until we gained a large lake. Pushing on from its northern extremity we traversed a mile or so of swale to come upon another lake of considerable size which lies about the center of the hunting grounds. The outlet to this was, after tedious search, discovered on the north side; being, in fact, the mysterious river spoken of by the Athabasca Indians. We began the descent, knowing not whether it had outlet in the Arctic Ocean or Hudson's Bay, although we fondly hoped the latter. This river throughout its length we found to be lacustrine, and much time was lost by this, as it was ever difficult to pick out the particular arm of each successive lake that gave egress to the river. Between these widenings out invariably occurred rapids, both lengthy and rapid, but the dexterity of our Caughnawaga steersmen brought us safely through all but an occasional stiff one that necessitated a portage. In August we came to a lake, which must be the Lake Dubaunt or Doobaunt so variously located on the maps. Although in midsummer, ice seven feet thick covered it, except close to shore, where, in a narrow channel, for

ROUTE OF THE TYRRELLS TO CHESTERFIELD INLET AND RETURN.

100 miles we paddled our way around in full view of the hillsides that were still covered with snow.

"From this time we were on the lookout for Chesterfield Inlet, as our observations for latitude and longitude helped us to a good idea of whither the river was bearing us, and about September 1 we reached the inlet's western extremity. We had with us some rough plans dating from the time when, in the middle of last century, expeditions were searching for a northwest passage to China, and now we made use of them, correcting by survey their many inaccuracies. In size this long river can best be compared among American rivers to the Ohio. On the 10th we drew up our canoes on the inhospitable shores of Hudson's Bay; certainly the first white men to cross the 850 miles intervening between the great inland sea and the Mackenzie and Athabasca basins, and as no record exists of an Indian having done it, most likely our voyage was through country never before traversed by man."

The explorer was asked concerning the physical aspect of this hitherto unknown territory. Said Mr. Tyrrell: "I may liken it to the prairie in a measure. It is a rugged, rolling tract of land, speckled over with swamps, and occasionally, rocky hills. In the whole Barren Lands there isn't wood enough to make a boot peg of, so that, though we were often wet, the luxury of a fire was impossible, and such game as we shot had to be devoured raw. My brother is taking down to Prof. Macoun at Ottawa a collection of flora, the more valuable as it is the first from the Barren Lands. We would often come to a stretch strongly reminiscent of the Northwest prairies from its thick covering of low growing flowers; and as a rule the ground is grassy. The lakes abound with fish, mostly trout and white fish; but here, except for the reindeer, appearances of animal life stop short.

"No birds; no wild fowl, save one or two solitary white partridges—brown at that season; no musk ox, although their presence might be expected; a few scattered white wolves, that is all, if you except the reindeer. And the big antlered fellows roam supreme in the Barren Lands. Once we saw a herd that fairly hid the earth for a whole three miles; and at the smallest possible calculation there could not have been less than several hundred thousand, feeding there on the damp grass. Only for the deer the party's larder would have failed entirely, as the dried meat constituted the principal diet.

"When we reached Hudson's Bay we had left only ten days' provisions after crossing this 'great lone wilderness,' but stayed round the mouth of the inlet for two weeks completing the surveys and observations. We left in the middle of September, just as the ice was beginning to form, and started by canoe on the 500 mile voyage southward to Fort Churchill, surveying the coast as we went. We soon discovered we had fared remarkably well on our overland trip in comparison with this progress in frail canoes on the high seas. Equinoctial gales and head winds prolonged our trip to one of 40 days' length. At first continual cold, driving rains brought us misery, and until the frost grew intense we had to sleep every night in our suits of reindeer fur and rabbit skin blankets, both wet. Although we landed at night time for a camp, it brought no relief, for within 400 miles there was not one stick of wood, and over everything lay eighteen inches of snow. Our provisions had long since given out and there were days when we lacked one bite to eat; on several others we managed to shoot two or three ptarmigan, or a like number of ground squirrels, but divided among eight, to be devoured raw, that could not be called fare any too ample. Sometimes our guns brought down a sea duck, when we got well off the coast, as in crossing deep bays, but they were poor substitutes for the shore duck that had all flown south. One lucky cartridge brought a polar bear into our clutches; he was devoured to the bones and skin.

"At one time we were two days on the sea at a time. To tell how it happened, I must explain that the tides were a source of perpetual annoyance and danger, rising from fourteen to eighteen feet. When the tide is out it leaves along the bleak and slightly elevated shore a belt of from four to five miles of shallows, dotted close with massive bowlders. To land in safety you thus have to pick your time when the tide is at the highest point; and on the occasion mentioned it was midnight, and snowing into the bargain. At another time we were unable to put to sea for five days.

"By October 16, we were still thirty miles from Churchill Factory's pretentious array of seven or eight houses, but the ice was forming so fast that progress by canoe was impossible. Every one in the party was very weak from hunger and exposure, but I sent the two strongest Indians on foot south for dog teams. They succeeded in hiring four, and also brought back much needed supplies, so that at length we got our canoes to Churchill in safety, the people being greatly surprised at seeing white men come from higher latitudes than even they inhabit. Here, because the river was not frozen, we had to delay two weeks, although part of this time we were glad of it. My strength gave way a short distance from the factory, I having to be carried in, and the condition of the rest was almost as deplorable from the trials of that trip down the bay. The legs and arms of every one in the party, shortly after getting there, swelled to over twice the natural size; but the kind attention received soon put us right again.

"With one dog team we started for York Factory on November 6, reaching the Nelson River in a week, but as it was full of floating ice, and we could neither ferry it nor cross on foot, another delay of ten days had to be submitted to, although we were just able to exist on the small game we could shoot. Finally, we crossed in a boat and were warmly welcomed by Dr. Milne, the chief officer at Fort York. On December 7, we reached Oxford House, 250 miles further in a southeasterly direction, having employed ten days in the walk on snow shoes alongside the dog team, and, after waiting there a few days for another dog team, we set out for Norway House, and arrived on December 20. Here with no trouble we secured four dog teams and made the 350 mile trip to Selkirk in the short space of ten days. This long snow shoe tramp from Churchill to Norway House made a total of about 600 miles, which is in itself quite a feat, considering that all the time the thermometer lingered about 40 below zero mark. We passed the nights under the open sky, going to sleep beside a fire that generally died before midnight; and our covering consisted of Esquimaux clothing and blankets made of rabbit skin. Yet we felt the cold very little and certainly it was an improvement on the coasting voyage, for I myself had already gained forty pounds in weight since leaving Churchill. Concerning the latter I may say that our survey will completely change the shape of the Hudson's Bay shore, as we are the first ever to come down the coast in canoes, and existing maps rely only on the few observations of sailing vessels that have taken a 'sight,' here and there, when lying-to from ten to twenty miles away.

"As regards the main objects of the expedition it was entirely successful; we have proved that, but for what minerals may be found among the very varied rocks of the Barren Lands, it is of small value."

Thus ends the history of the longest trip through entirely unknown portions of the continent undertaken since Sir John Franklin was engaged in his ill-starred Arctic expeditions. The total mileage by canoe was 2,200, of which 850 was through new country; the total by snow shoe travel was 650, and by dog sled 350.—*Buffalo Express.*

IMPERVIOUS SACK OR SACKING.—The sacking consists of a woven fabric or ordinary sacking of either flax, jute, or hemp. It is coated on one side with a compound adapted to render it impervious to damp or atmospheric influence. This compound consists of a mixture of artificial bitumen (refuse from petroleum distillation), 60 to 80 parts, pitch, such as is obtained as refuse in the saponification of palm oil, 5 to 20 parts, and chalk about 20 parts. After application of this mixture, a layer of thin paper is pressed down upon it, so as to act as a protection against adhesion of other matters. This sacking may be prepared in the piece and then cut up to form sacks or bags. A machine for the application of the compound to the sacking forms part of the claim.—*E. Pierret, Vilvorde, Belgium.*

THE PHYSIOLOGICAL AND PATHOLOGICAL INFLUENCE OF VEGETABLES UPON MAN.

By MARK I. KNAPP, Member of the Senior Class of the University Medical College, New York.

MAN is made up of a multitude of elements and compounds, each of them having its exact destination and each being necessary to his constitution. Each and every one of those chemicals which make up our tissues are constantly undergoing changes, are eliminated, and must consequently be supplied with new material. Must we not, therefore, be on our constant lookout to supply as well our used-up nerve tissue as the muscular and glandular structures, fat, bone, etc.? Remembering the diversity and multiplicity of the components of the many tissues that make up our system, can we then confine ourselves to only one certain diet? Can we feed a man with only certain articles, excluding others, without a necessary reaction or disturbance taking place? Or, have all our articles of nutrition the same chemical composition which would make a selection immaterial? No, the same chemical constituents that meats have, vegetables have not; and even if they have like quality, they do not have like quantity. The albuminous matters are in different proportions in meats and in vegetables. The proportions differ in different kinds of meat and in different kinds of vegetables; and if we have enough of nitrogenous substances in a pound of meat to supply the waste of one structure, we lack the proper amount of earthy salts to satisfy other tissues. We can, therefore, neither confine ourselves to the exclusive use of meats nor to that of vegetables; they are of like importance to sustain our equilibrium of health and life.

A few analyses, taken from "Chemie der menschlichen Nahrungs und Genussmittel," by Prof. Dr. J. Konig, of Berlin, will conduce to a better understanding.

From these analyses we see that meats, peas, beans, and some fruits are rich in albuminous substances; whereas vegetables consist of a relatively very large amount of salts, hay being very rich in calcium salts. Whereas in taking 100 gm. of albuminous matter out of the ox's meat, we would only have 5·61 gm. of salts, we should have to ingest 65·07 gm. of salts to cover the same amount of nitrogenized substance when we take cabbage, or 29·01 gm. if oats be selected as the exclusive food, or 50·256 gm. of salts if potatoes should be the nourishment. It is therefore evident that, in order to supply the necessary quantity of albuminous matter out of vegetables, we must ingest a large amount of salts. Again to cover our lack of salts in an animal diet, we would need to take an enormous volume of it—which would be impossible for us to do. Hence by confining ourselves to an exclusively animal diet, the tissues that depend for their existence chiefly on salts will suffer; and if preference be given to vegetables, other structures will give symptoms of insufficiency in supply. It is also to be noted that sodium is prevalent in the composition of animal tissue, potassium in that of vegetables; consequently with a larger supply of animal diet, we also introduce more sodium into our system. The necessity, therefore, suggests itself to know at each period of our life the nature, quality, and quantity of the chemical elements or compounds needed by our economy, since our system is always changing, and consequently also our diet will have to vary accordingly. That menu prescribed for the developing infant or child will not hold good for the adult, and *vice versa*. At the same time, finding one article to be predominantly used at a certain period of our life, we should not drive it to an excess; for any excess of one means and causes an insufficiency of the other, and consequently doing away with the necessary equilibrium, it causes insecurity, danger, *i. e.*, it hurts.

	Water.	Nitrogen. substance.	Fat.	Extracts.	Salts.	Sugar.	Dextrin.	Starch.	Woodfiber.	Ashes.
	%	%	%	%	%	%	%	%	%	%
Ox meat, very fat	72·25	20·91	5·19	0·48	1·17	....	....	....	....	....
Cow meat, fat	70·96	19·86	7·70	0·41	1·07	....	....	....	....	....
Cow meat, lean	76·35	20·54	1·78	....	1·32	....	....	....	....	....
Veal, fat	72·31	18·88	7·41	0·07	1·33	....	....	....	....	....
Veal, lean	78·82	19·86	0·82	....	0·50	....	....	....	....	....
Mutton, fat	47·91	14·80	36·39	....	8·85	....	....	....	....	....
Mutton, half fat	75·99	17·11	5·77	....	1·33	....	....	....	....	....
Pork, fat	47·40	14·54	37·34	....	0·72	....	....	....	....	....
Pork, lean	72·57	19·91	6·81	....	1·10	....	....	....	....	....
Beans	13·74	23·21	2·14	53·67	....	....	....	....	3·69	3·55
Peas	14·99	22·85	1·79	52·36	....	....	....	....	5·43	2·58
Wheat	13·56	12·35	1·75	....	....	1·44	2·38	64·08	2·53	1·81
Barley	13·77	11·14	2·16	....	....	1·56	1·70	61·67	5·31	2·69
Oats	12·37	10·41	5·28	....	....	1·91	1·79	54·08	11·19	3·02
Potato	75·48	1·95	0·15	....	....	....	....	20·69	0·76	0·98
Turnips	89·42	1·35	0·18	3·14	....	4·22	....	....	0·65	0·75
Melon	89·87	0·98	0·28	6·57	....	0·57	....	....	1·05	0·70
Asparagus	93·75	1·79	0·25	2·26	....	0·37	....	....	1·04	0·54
Cabbage	89·97	1·89	0·20	2·58	....	2·20	....	....	1·84	1·23
Spinage	86·47	3·49	0·58	4·34	....	0·70	....	....	0·93	2·09
Parsley	85·05	3·66	0·72	6·60	....	0·75	....	....	1·45	1·08
Dandelion	85·54	2·81	0·69	7·45	....	....	....	....	1·52	1·90
Nettle	82·44	5·55	0·67	7·13	....	....	....	....	1·96	2·30
Wormseed	80·80	3·94	0·76	8·93	....	....	....	....	3·82	3·02
Walnut	4·08	16·37	62·86	7·89	....	....	....	....	6·17	2·08
Hazelnut	3·77	15·62	66·47	9·08	....	....	....	....	3·28	1·83
Cocoanut (fresh)	5·32	5·49	36·16	8·06	....	....	....	....	2·91	1·55
Iceland moss	15·96	2·19	1·41	76·12*	....	....	....	....	2·91	1·41
Banana	73·10	1·87	0·63	23·05	....	....	....	....	0·29	1·06

* Of which 55·65 per cent. is starch.

As a rule, we understand by the expression "nutritious food" albuminous matter; whereas it should convey to our mind the idea of such substances as are necessary to all the different tissues of our body, and certainly albumen is not the only thing that is indispensable. That nitrogenized substances are not the ideal predominable nutritious food for the infant and early childhood, that we must not overcrowd the young growing child with albuminous matter, will readily be seen from subsequent remarks.

The framework of anything is the basis of everything, and upon a sound and solid foundation the future existence, solidity, and durability of the whole building depends. However beautifully, artistically executed, the building is always in danger of breaking down if the foundation be not properly secured. It shall therefore be our duty and our first thought to secure, fortify, and strengthen also our framework. What else is our framework but our skeleton, our bones? To strengthen, insure durability, to cause developing, growing of bone in the young children, we naturally must introduce into the system bone-forming elements, substances of which bone can be formed; and since bone consists chiefly of earthy salts, since the earthy phosphates constitute two-thirds of the constituents of bone, it will be necessary to introduce into the young, growing system such substances that are rich in salts, which substances belong not to the animal but vegetable kingdom. The same view is also expressed by Konig, who says: "For the growing organism earthy phosphates are of great importance, for out of these the bony skeleton is built up." This innermost, unconsciously felt desire for earthy salts and vegetables we often have occasion to observe in small children. Not unfrequently do we wonder at the perverted appetite of those little ones whom we find at times eating chalk, shells of eggs, etc. They feel and know what they want. Many children can hardly be induced to taste meat, whereas to vegetables they take readily.

The physical development of man depends upon his height and circumference, the causative factor of the first being the relative skeletal development. Of two men, short and tall, both of whom being proportionately built, the taller has a stronger and a more durable constitution; we must consequently, in order to insure strength, insure height, and to do this we must cause growing of bone by the proper vegetable diet. But since bone, like other tissues, is also always undergoing change, *i. e.*, eliminates used-up matter and takes up new, the necessity of not losing sight of the importance of vegetables throughout life is apparent. We also find that the ancient Roman and Greek athletes ate no meat. From all said until now, we should infer that the height of man and all animals depends upon the growing of their bones; this latter upon the proper nutrition—an assertion also expressed by Paolo Riccardi. *Only the sufficient or insufficient supply of vegetables determines the respective height of all animals and man; an abundance of vegetables which contain the earthy salts brings forth tall, an abundance of albuminous animal diet—insufficiency of the bone-forming salts—is thecause of the non-development of skeleton of the short people.*

Heredity and climate have been thought as probable causes of development of stature by some, who necessarily had to find an external cause for simple phenomena. Neither climate nor heredity directly influence the height of man or of animal. Nor is it the altitude. For we find tall and short men in the same village, in the same city, in the same country; we see tall people of very short parents, and *vice versa*. We meet with tall and short people in the mountainous regions, as well as in the deep valleys; tall and small men are encountered along the sea coast, as well as in the very heart of the continent. Could it be then anything else but the difference in diet that influences the growth of man and animal? Could it be anything else but the difference in the material supplied, that causes difference in appearance, quality, and durability of the machine or building produced by such material? Is it not self-evident that food, and food only—that which is absolutely necessary to give to the living, life—also determines life? That with a suited nutrition growth is produced, and with a diet wanting the necessary ingredients neither growth nor long life can be sustained. Should we not look for physical and chemical causes only to explain our chemical and physical phenomena of life, instead of looking and seeking for as many causes for as many phenomena?

Of the fact that only a vegetable diet produces height of animals and man, there is sufficient proof. We only compare the two great classes of animals, the "herbivora" and "carnivora," and the most striking difference, not only in height, but also in other respects, is at once seen. The herbivora, the older animals of our planet, are proportionately built, the carnivora not. The height of the herbivora corresponds to the length of their body; in the carnivora the body is longer. The head of the herbivora is much larger than that of the carnivora. Herbivora are known to reach an age of up to two hundred years (elephant). Carnivora die very much earlier. Compare side by side the giraffe, elephant, camel, ox, horse, sheep, goat, with the lion, tiger, bear, fox, cat, and see the height attained by the first exclusively vegetarians; see how proportionately they are built, their height equaling the length of their body, whereby the best of all proportions, that of a square, is given to them, and observe the shortness of legs in the carnivora. In all of these latter, the body length is greater than their height. The mastodon and other prehistoric, very large animals, were herbivorous, as seen by the formation of their teeth. Here, certainly, nothing else but the difference in nutrition can make that diversity in appearance and character of those animals, those children of nature upon whom civilization and progress of science cannot pour its enlightening rays. Climate and altitude have no influence here either. For both herbivora and carnivora live in the same woods, on the same mountains, in the same valleys, and necessarily the carnivorous must live where the herbivorous exist. Heredity could be brought up here probably better than in man, but of whom did the first carnivorous animal inherit his shortness?

Not only, however, does the animal kingdom give us more than sufficient proof of the fallacy of any other theory than diet as the cause of height, also the ethnography of man, who has not yet been brought into intimate connection with the civilized world, proves it with certainty and positiveness.

Even at the present time, almost debarred from any industrial and commercial intercourse, many human tribes exist who are restricted to the products of their own land only, who have to live upon what only their own country grows, many human races who know nothing of agriculture, either of their own fault or that of their climate. The blessing of the rapid railroad train, that medium which serves as an equalizer and rapid distributer of the goods and products of one country to others, that medium which makes failure of crops of one region unfelt by the immediate introduction of superabundance from elsewhere, are as yet unknown to many peoples. Many of these yet live in a primitive state, varying in their daily habits only very slightly or not at all, and consequently can be studied and inferences from them can be much more readily and easily drawn than from civilized people, whose habits regarding diet are much more complex. Such primitive races are found in the north as well as in the south, and like these extremes of climate also, those tribes are extremes in regard to their nourishment and consequent height. The one occupying the north, the Esquimaux, Samoyedes, and the Lapps, are the races known as the shortest; the tallest known are the Patagonians and Polynesians, who inhabit the south. What a difference of diet in those extremes!

Fr. Muller (Reise der osterreichischen Fregatte Novara um die Erde, Ethnographie, Wien, 1879) gives us the following account: The nourishment of the Polynesian was always predominantly of a vegetable nature. Roots of ferns, berries, cabbage shoots, bread fruit, cocoanut, manioc, and sweet potatoes formed the chief nourishment; animal products were taken seldom, as a rule only at festivities.

From Friedrich Ratzel's Volkerkunde I took the following extracts: The Hyperboraei do not belong to the tall-grown. A Samoyede—a tribe of Northern Siberia—of 150 cm. height, Middendorf regards as tall among the dwarfs. The shortness of legs of all these races is striking, to which shortness of legs in the case of the Lapps also shortness of arms corresponds. The best foods preferred by them are: Reindeer flesh, dried blood, the contents of the stomach of the reindeer, eggs, some roots, and mossberries. In another chapter, treating of the same short people, he says: "Fishing is the chief source of nourishment besides hunting and reindeer breeding. The nourishment of the nomads of North Asia is pre-eminently of an animal nature. The Obongos, a family of African dwarfs, are experienced hunters; their nutrition consists predominantly of animal matter."

Rev. S. W. Kolle relates, in his "Polyglotta Africana," that a man of Pati, the residence of Bayon (landinwards of Cameroon), told him there lived at the sea Liba a tribe only three to four feet high; Kenkob was their name, strong people, excellent marksmen, peaceable, and very liberal men, who lived from the results of their hunting.

According to Emin Bey, who in the year 1882 came in contact with the Akkas, a family of dwarfs in Central Africa, his measurement of a twenty-four year old man gave a height of 124 cm., and that of a thirty-five year old man 136 cm., height; they are a good and genuine hunting tribe.

Do not these extracts from very competent authorities give us the true and the most satisfactory evidence that to the nutrition, that to the diet only, the height of man is to be ascribed? that the tall man is indebted for his body length to the abundance of vegetables he takes, and that the exclusive animal diet, the insufficiency of the earthy salts, keeps back the development of the skeleton, keeps back, restricts, the growth of bone, and thus is the cause of the short man? Does it need any better or more convincing facts?

I myself have not yet failed in correctly telling a person his likings, whether he rather ate vegetables or meat, which I inferred from his stature; the above theory proved to be correct, proved to be a fact in every instance without exception. The short man is fond of meat, without which he says he could not live; indifferent to it is the tall man. "I must have soup and vegetables every time;" about meats I don't care very much," the latter says. "If I should always have my own choice," one tall man told me, "I would always take vegetables."

Of two children, both girls, the one living in our house, the other the child of a friend of our family; the first being about three, the second about five years of age; the first child is strong, robust, fat, and large for her age, the second is small and thin, and everyone remarks "she never grows." As to their diet, the first one, says the mother, eats much potatoes, bread, soup, and vegetables, little meat; the latter gets no vegetables at all, or only very seldom, although she takes them, if given to her, with great avidity, and must be forced invariably every time to take meat, which the child gets every day, sometimes several times during the day. Another fact—Mrs. F—, thirty-five years of age, rather above woman's average height, not exactly tall, corpulent and strong, when asked whether she liked and ate much meat she replied in a certain tone of pride and self-reliance, "I don't relish meat at all. I must have potatoes at every meal and enough of them; very often I leave the meat untouched. I never did care for meat." Also other vegetables and cereals form factors of her meals. Her husband is tall and shares the same views with his wife regarding diet. What wonder if her children (boys) are also tall? Is it heredity? Have her children inherited the tall stature of their parents? No; decidedly not. "A bove majori discat arare minor." As infants and in early childhood they were simply brought up to the same conditions as favored by their parents, as their parents, judging from their own likings, thought wise and correct; they were subjected also here, as in many other cases of supposed heredity, to the influence of the same causes that typified their parents; also they have received largely a vegetable diet, considered by their parents as the proper one, they were not asked but given, and of course, as to be expected, the same conditions obtained.

The rejection of meat, so common in pregnant women, and coming on about the beginning of the third month, *i. e.*, commencement of ossification in the fœtus, and at the same time "the capricious appetite, which assumes the form of longing for strange and even disgusting articles of diet" (Playfair), are again proofs for the insufficiency of vegetables, of the bone-forming salts, in the then present condition of the woman's system.

Not only is height dependent upon a vegetable diet, also longevity and mental development are largely influenced by it. This we may infer from the fact that people in bygone years and centuries, at a time when meat was consumed much less generally and in much less quantities than it is now, not only were larger but also lived longer. It is self-evident that a structure constantly being kept in repair, a building whose main walls of support are constantly looked after, and any damage, slight as it be, immediately remedied, will naturally last longer. Again, it is also known that the first to suffer, in another building left to itself, are those parts upon which the safety of the house rests,

and not the facades or any other ornamental work. Just the same is it in man. Bone is the first to show signs of weakness when all other organs still do their work satisfactorily. This, however, is conjecture, and even if vegetables are not the only causative factor of longevity, a factor they certainly are.

Regarding their effect upon the mental faculties, vegetables seem to be of a negative nature. Here again the herbivora and carnivora give us satisfactory proof; higher mental development we find in the carnivora.

To account for the necessity of vegetables to height is easy enough, but I could not yet find any reason why meat should have that effect upon the brain that it does have unless that it is reasonable to judge *a priori* "food of a higher organic development must also bring forth higher mental development." Or the more readily coal, wood, or any other material burns, the larger and brighter is the fire. The more readily the food brought into the stomach is burned up, digested, the brighter is also the fire here, and since meat is more readily and completely digested and assimilated, the greater probably is its stimulating effect upon the nervous system. (The fluid in the cerebral ventricles consists almost exclusively of sodium chloride. Is it the greater quantity of the sodium that is taken in with the animal diet that stimulates the brain? Sodium predominating in animal, potassium in vegetable tissue.) In the case of the two children related above, the small one—fed mostly on meat—evinces remarkably high mental faculties for her age, whereas the other, the large, with a vegetable diet, shows nothing of sharpness of mind; in fact, rather the reverse is true. We had delight in talking to the first—smaller child—as soon as she could express herself distinctly.

So much for what we may call the physiological effects of vegetables. Now let us consider their pathological influence, if used in insufficient quantity or ill proportion.

The deleterious effects of abstinence from vegetables for a length of time has been recognized already in scurvy. But also in rachitis, lack of earthy salts, *i. e.*, insufficiency of vegetables, is doubtless the cause. Such was my opinion, such was my conclusion about a year ago, when after some time of observation I noted the fact of the influence of vegetables upon growth, and only a few weeks ago when looking around for some book which treated of the chemical analyses of food stuffs and found Koenig to answer my purposes, I read in the same book the confirmation of my views by several authorities; also according to these, insufficiency of vegetables causes rachitis, not the lactic acid. Following are the extracts taken:

Experiments by F. Roloff* prove that in young growing animals with insufficiency of lime and phosphoric acid, diseases of the bones always manifest themselves, and that, the stronger and sooner the greater is their insufficiency. Also the many experiments by E. Voit and Fr. Tuczek† gave the same results. The researches of Hofmeister and Siedamgrotsky‡ prove that the addition of more or less lactic acid, given together with enough of calcium phosphate (hay) produced no such symptoms as are characteristic of osteo-malacia or rachitis, a disease due to lime insufficiency." Rachitis is a disease of the children of the poor, who in the larger cities cannot afford to buy vegetables, which are there much more expensive than meat. These poor children are fed largely on beans, peas, meat and potatoes; the relation between albumen and salts in the first three being nearly the same, and of the latter, the starch being the principal part, they cannot digest enough to give them the necessary quantity of salts. Osteo-malacia is also common in "women who have borne many children," *i. e.*, women who had to give off bone elements from their own constitution to supply the demand of the developing fœtus.

Gout is another disease acknowledged to be due to a high nitrogenous living among others, also to excess of meat.

Laboring under the impression that excess of one means diminution, insufficiency, of the other, that therefore excess of meats means insufficiency of vegetables, I had the opportunity to experiment on a gentleman, Mr. N——, whose urine I examine every month. This is the history: The first analysis I made on May 2, 1892, when I looked for albumen, sugar, excess of phosphates, and although the color of the urine did not indicate any bile or blood, yet I did it for the sake of thoroughness. Regarding these I found nothing abnormal. On July 19 followed the second analysis, when I looked for the same and found the same as on May 2. The third analysis, on August 16, resulted similarly. On September 20, however, I recognized hyperacidity, which led me to look for excess of urates, which I found. Being asked by that gentleman the cause of the excess of urates, I answered, it may probably be due to the bottle, which was not the same as the other three times, and which contained some kind of drug before it was filled. On October 15 I found nothing abnormal; whether it was a faulty analysis or not I could not tell. But the following three analyses, those of November 12, December 24, and especially that of February 4, 1893, were charged abundantly with excess of urates. Mr. N—— asked me what harm might arise, to which I responded, it may lead to stone in the bladder or gout; and as his brother has already had several attacks of gout, I told him he was likely to get it unless he changed his diet, which consisted of meat three times a day, and some spirits; of vegetables, which he absolutely disliked, he took very few potatoes. My advice was, not to stop his meats, beer, or wine, but to have plenty of vegetables at every meal, which of course itself must diminish the quantity of meat, the stomach having been satiated already by vegetables. Mr. N——, who is a graduate of the City College, a member of a downtown wholesale firm, and of good social standing, thought there was a difference between fluid and solid meat, abstained from the first, and with the latter he took sufficient vegetables. I was surprised not to find any trace of excess of urates at the next analysis, March 18, since which time the urine remained normal, Mr. N—— now being fond of vegetables.

The deposit of urates in the joints may probably be due to the following chemical changes: Uric acid, an animal product, found only in the carnivora, not herbivora, is produced only by animal and not by vegetable tissues. Consequently an increased supply of the material will increase the quantity of the output, *i. e.*, increased animal diet will increase the volume of uric acid in man. Finding no substances which, if vegetables were taken the free sulphuric acid contained in them would counteract, the excessive amount of the uric acid circulating in the body combines with the sodium (which with increased animal diet is also increased) of the synovial fluids to form the urate of soda, which is deposited. That the great toe is usually first involved may be due probably to the fact that the great toe joint is the least disturbed or exercised of all the other joints in the body and therefore any formation of deposits is undisturbed.

Related to gout, the difference being probably one of degree, is rheumatism. Here, as in gout, the joints are the site of disease; here, as in gout, there is "hyperacidity," or diminished alkalinity of the blood; here, as in gout, exists an ill proportion between meat and vegetables. Of the four patients I saw in Bellevue, 1, John C. O'C——, aged forty-three, admitted October 1, 1893; 2, Charles B——, admitted September 21, 1893; 3, Nicholas M——, admitted March 22, 1893; and 4, Alfred K——, admitted October 2, 1893—there were no more in our wards at that time—every one preferred meat, which they had taken several times a day, almost abstaining from vegetables; also to them meat was the nutritious food, the diet. In gout the excess of meat is apparent, easily detected, in rheumatism, a disease more of the lower class, the deficiency of vegetables is of a slow coming character. That in fishermen exposure to wet and cold should be regarded as the cause is not necessary; these people live on an animal diet almost exclusively. How well can each of the symptoms of rheumatism be explained should insufficiency of vegetables, or what is the same thing, excessive consumption of meat—the cause of the hyperacidity—be considered the etiological factor. Skin diseases and all other diseases that are the result of hyperacidity of the blood may thus have for their first, predisposing, if not exciting cause, an ill proportion between meat and vegetables, the predominating one being meat.

If the foregoing be recognized, would we not be just in saying that as well as excess of meats, also excess of vegetables must induce sooner or later a pathological condition? that excess of vegetables or diminished quantity of meat may be the idiosyncrasy, predisposing or exciting cause, of another class of diseases?—*Medical Record.*

* Zeitschr. d. landw. Centralvereins d. Prov. Sachsen, 1875, p. 261.

† Zeitschr. f. Biologie, 1880, vol. 16, p. 55.

‡ Mittheil. aus d. chem. phys. Versuchs station d. Thierarzneischule zu Dresden.

BANANA CULTURE IN JAMAICA.

In years gone by Jamaica, the Eldorado of the West Indies, was in a more prosperous state, when the sugar and rum traffic were productive of wealth; but, since introduction of beet root sugar into the European market, the cane sugar industry has rapidly declined.

Many large sugar estates, once richly productive, says Prof. W. S. Windle, in the current number of *To-Day*, are now deserted or devoted to other agricultural pursuits. During recent years, however, a comparatively new industry—that of banana culture—has arisen, which promises to replace the loss, in part at least. It is chiefly controlled by the Boston Fruit Company, which employs a line of eight or ten fruit steamers that ply, during the greater portion of the year, between the ports of Jamaica and the ports of Boston, Philadelphia, and Baltimore. The extent of the traffic may be estimated from the statement that each steamer averages a trip every three weeks, and carries from 12,000 to 20,000 bunches of bananas as a cargo. That the trade is rapidly growing is shown in the statistical report of Jamaica, which gives the shipment of bananas to the United States and Canada as follows: 301,991 bunches in 1889, 445,512 bunches in 1890; showing an increase of 143,521 bunches in one year.

To the student of nature, says Prof. Windle, a thrifty, full-grown banana plant appears as the grandest of herbaceous products. It makes a remarkably rapid growth, reaching the height of from nine to twelve feet in as many months. Its stem-like trunk of from four to six inches in diameter is formed of thick sheathing leaf-stalks, from the top of which spreads a loose cluster of immense long leaves. These are often fifteen inches in width and six feet in length, and, when first unfolded, are transparent and of a bright green color.

Their edges are smooth and unbroken until the broad, green surfaces, exposed to the sun, wind, and rain, become lacerated into transverse ribbons—wrecks only of early symmetry. The plants are grown annually from sprouts that spring from bulb-like roots around the parent stem. They need but little cultivation. Deeply rooted in the rich soil, watered by copious showers, and warmed by the rays of a genial sun, they grow most rapidly. In seven months a long spike, bearing clustered flowers, surrounded by colored bracts, shoots forth from the clustered leaves, and minute bananas soon appear at its base, leaving the sterile plummet-shaped portion of the spike to extend beyond the bunch that is now rapidly forming.

In nine or ten months after planting, the fruit is gathered and taken to market. The bunches are always cut from the plants while green, to secure transportation, and also to obtain better flavored and less fibrous fruit. They are conveyed to the nearest seaport in large spring wagons, drawn by oxen, to be stored in the slatted bins of large banana houses, where they await the arrival of the next fruit steamer.

The varieties of the banana were found by the author to be as numerous as the kinds of apple in our orchards at home. A small red one, the Chinese banana, is prized very highly in Jamaica and elsewhere for its delightful flavor. The Maiden and Baracoa varieties are also small and of a red color, valued alike for sweetness and delicacy of flavor.

Another member of the same genus is the plantain, which, in tropical America, is far more extensively used than the banana. It is seldom eaten raw, but is boiled or roasted, or cut into long, thin slices and fried in butter. The flavor of the plantain does not equal that of the banana, which is usually eaten, when ripe, directly from the bunch. Bananas, however, are often cooked, eaten as preserves, or made into delicious custards, ices, etc.

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